United States Department of the Interior
FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

IN REPLY REFER TO:
FWS/EC-02-082

September 12, 2002

Mr. Gary Page
Wetland Program Director
Point Reyes Bird Observatory Conservation Sciences
4990 Shoreline Highway
Stinson Beach, California 94970

Subject: Request for Additional Information on the Moss Landing Management Area Improvement Project

Dear Mr. Page:

Thank you for providing the Command Trustee Council with restoration project proposals and for providing comments on the 'Command Oil Spill Public Scoping Document for Restoration Planning.' Both your comments and project proposals will be considered during the preparation of a Draft Restoration Plan/Environmental Assessment (RP/EA). The Draft RP/EA will be made available at a later date for public review and comment, and we will add your name to our current mailing list.

We have screened all comments, received to date, and would like to hear more about your proposal to improve the Moss Landing Management Area. Specifically, we are interested in the following:

1. Description and explanation of how the proposed project would specifically meet selection criteria listed in the Command Public Scoping Document.
2. Estimated project costs and a description of the financial and regulatory feasibility of the project.
3. More detailed description and explanation of the benefits that would be derived from the restoration proposed to those injured resources addressed in the Command Public Scoping Document.
4. Contact information identifying personnel who can answer questions about your proposed projects.

Information provided will be used to assist the Council in developing and writing the Draft RP/EA, and the process for final project selections will be outlined in the Command Final Restoration Plan. If you have any questions please contact Charlene Hall at 916-414-6600 or visit the "Command" website at: www.darcnw.noaa.gov/command.html or www.dfg.ca.gov/ospr.restorations.html. Thank you for your interest in the Command Oil Spill Restoration Project.

Sincerely,

David L. Harlow

David L. Harlow
Acting Field Supervisor

United States Departme
FISH AND WILDLIFE
Sacramento Fish and Wil
2800 Cottage Way, Roo
Sacramento, California 9

IN REPLY REFER TO:
FWS/EC-02-082

RECEIVED
JAN 02 2003
SACRAMENTO
FISH & WILDLIFE OFFICE

Hello David,
In response to this letter
I have finally produced
the enclosed information.
While probably too late,
better to produce this
rather than nothing. Again
sorry for being so slow
to respond-
Sincerely
Gary Page

2

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Sincerely,

David L. Harlow

David L. Harlow
Acting Field Supervisor

PRBO Conservation Science
4990 Shoreline Highway
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prbo

December 29, 2002

Trustees for Natural Resources Injured by the Command Oil Spill

Dear Trustees,

I am writing to provide additional information in support of the Brown Pelican roost enhancement and protection project at the Moss Landing Wildlife Area.

Moss Landing Wildlife Area consists of about 150 acres of retired salt ponds near the entrance of Elkhorn Slough, Monterey County. The ponds were purchased by the California Department of Fish and Game (DFG) in 1984 and converted to managed ponds for wildlife between 1989 and 1991. DFG's restoration goals were to provide nesting habitat for Snowy Plovers and roosting habitat for Brown Pelicans. An island was constructed in one of the ponds for the pelicans. It was intended that water would be moved through a water control structure from Elkhorn Slough into a holding channel. From the holding channel water would be moved through a series of ponds including the one containing the island.

The managed ponds have never functioned as intended because it has not been possible to move water into the ponds easily. Water can only be put into the holding channel on the highest tides and it is not possible to get water into some of the outer ponds at all. Also, it has not been possible to surround the island with water in late summer and fall when pelicans would be expected to roost there.

Since 1995 PRBO biologists have been managing the ponds for nesting Snowy Plovers. By trapping water in the holding channel during the highest tides and then metering the water into burrow ditches (excavated in ponds to create the levees) it has been possible to enable plovers to nest in the dry pond bottoms then move their chicks to the water-filled burrow ditches to feed.

The ponds have been a productive breeding area for Snowy Plovers since PRBO began managing water for plovers. From 1995 through 2002, on average, 48% (SD = 17.4%) of all fledged chicks (hatched chicks reaching flying age) from the Monterey Bay shoreline were from the managed ponds (Table 1). Since 1999, 35-48 males and 30-45 females have breed in the salt ponds annually. The largest numbers (48 males and 45 females) nested in 2002.

Brown Pelicans also roost in the ponds. Although Brown Pelicans have never used the island, PRBO biologist learned that when ponds were very shallowly flooded they

attracted large numbers of roosting pelicans, particularly at dusk. They estimated up to 3,000 pelicans roosting in shallow water ponds. Thus by providing shallowly flooded habitat in some ponds it is possible to establish a large pelican roost in the wildlife area.

Table 1. Percent of fledged young from the shoreline of Monterey Bay reared by Snowy Plovers nesting in the managed ponds from 1995 to 2002.

Year	% Fledglings From Ponds	Total Number of Fledglings
1995	25.0	108
1996	46.1	128
1997	59.4	138
1998	57.1	133
1999	80.0	85
2000	47.2	142
2001	34.3	265
2002	34.6	211

It has never been possible to manage the ponds as originally planned because of the high elevations of the pond bottoms relative to sea level. Additionally, the original water control structures have corroded and now leak badly. Vegetation is evading the outermost ponds making them unusable by Snowy Plovers and other shorebirds. The bank of the slough near the main levee has eroded badly. If it is not fortified it will continue to erode until the main pond levee is undercut causing the area to become tidal.

Ducks Unlimited, DFG and PRBO are collaborating on a proposal to restore the ponds so that they can be managed more effectively for nesting Snowy Plovers, roosting Brown Pelicans, and other aquatic birds such as migrating and wintering shorebirds and waterfowl.

The draft restoration plan (see attachment Moss Landing Salt Ponds Habitat Enhancement Plan) proposes to expand the holding channel and replace failing water control structures. Additional water control structures are to be added so that water levels in each pond can be managed independently. The main levee will be reinforced to maintain the integrity of the managed pond system. It is estimated to cost about $750,000 for the structural changes.

The Wildlife Conservation Board (WCB) has committed $650,000 and the National Fish and Wildlife Foundation (NFWF) $100,000 for the project. DFG and Ducks Unlimited are commencing on the permitting process. Some NFWF funds can be used for permitting, expected to be facilitated through a contract with a consulting company with expertise in the NEPA and CEQA process.

The project addresses two major goals of the trustees. It aims to provide roosting habitat for thousands of Brown Pelicans, one of the species impacted by the Command Spill. Secondly, by providing high quality nesting habitat for the Snowy Plover it increases

opportunities for the public to use Monterey Beaches because it reduces the dependency of the plovers on the beaches. Several portions of Monterey Bay beaches have been closed to the public during the plovers nesting season to reduce the impact of human recreation on nesting success. The salt ponds are already closed to the public and support substantial numbers of nesting plovers. Maintaining the ponds as productive plover nesting habitat will reduce the need for further beach closure.

Beside the plovers and pelicans, the ponds should benefit nesting avocets and stilts, and provide winter habitat for other shorebirds and waterfowl. Even under current circumstances we have shown the ponds can be a valuable plover nesting area and an important pelican roost. Restoration of the ponds should insure that these benefits persist for a long time. Appropriate permits will be obtained to make certain the project complies with applicable laws. We are unaware of any public health and safety issues associated with the proposed project.

After the ponds are restored it will be necessary to manage water levels and other pond attributes year round and to monitor the response of all target species to maximize the benefits for all species. Some of the key management activities are:

- Maintain water year round in cells with too much vegetative growth to kill back the vegetation.
- Draw water down in one or more cells in April for Snowy Plover nesting. Let other cells dry up naturally.
- Maintain shallow water areas in channels as foraging areas for adult and chick Snowy Plovers during summer.
- Maintain water in the reservoir cell throughout the summer so that it is available for metering into the cell channels during the summer.
- Flood all cells in August when Snowy Plovers finish nesting and maintain them in a flooded condition until the following spring.
- Maintain shallowly flooded areas for roosting Brown Pelicans.
- Counter the effect of winter storms by lowering water levels when necessary to prevent levee erosion.
- Control weedy levee vegetation.
- Create micro topographic relief in pond bottoms for nesting plovers.

Currently DFG allows PRBO biologists to manage the ponds for nesting Snowy Plovers during the summer. Monitoring the plovers' response to the management actions involves finding nests and maintaining a color banded population of plovers. PRBO biologists document the number of nesting adults, number of nests, number of successful nests, causes of nest failure, number of chicks hatched, and number of chicks fledged. PRBO employs one biologist from March through September to conduct these activities. PRBO biologists do not currently closely monitor most other wildlife using the ponds, except those species that might impact nesting plovers.

The Trustees could enhance the restoration project by adding a management and monitoring component for the initial years after the restoration project is completed to

maximize the effectiveness of management actions on Brown Pelicans and other migrating and wintering waterbirds. For monitoring pelicans, Deborah Jaques (pers. comm.) suggested year-round surveys with an emphasis on summer and fall. Surveys should be conducted during both daytime and nighttime and include data on number of birds, cells selected for roosting, and water depth of the roost sites.

The managed ponds should also support a wide variety of other aquatic birds, especially wintering shorebirds and waterfowl. These should be monitored from fall through spring, twice per month on both a high and a low tide to determine how management for these species could be best integrated with management for plovers and pelicans. Data collected would include: species, numbers, location (between cells), behavior (roosting versus feeding), water level, and salinity.

The monitoring program would extend for three years following restoration of the ponds with the goal of developing long term management practices to effectively integrate pond use by nesting Snowy Plovers, roosting Brown Pelicans, and migrating and wintering shorebirds and waterfowl.

I suggest $50,000 per year for three years (total = $150,000) primarily to cover a half time position for a person to manage the ponds and monitor wildlife, particularly in fall and winter after plover nesting. Included within the $50,000 would be a small budget of $5,000- $10,000 for equipment purchase and rental.

Contacts for the project are:

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Ducks Unlimited
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PRBO Conservation Science
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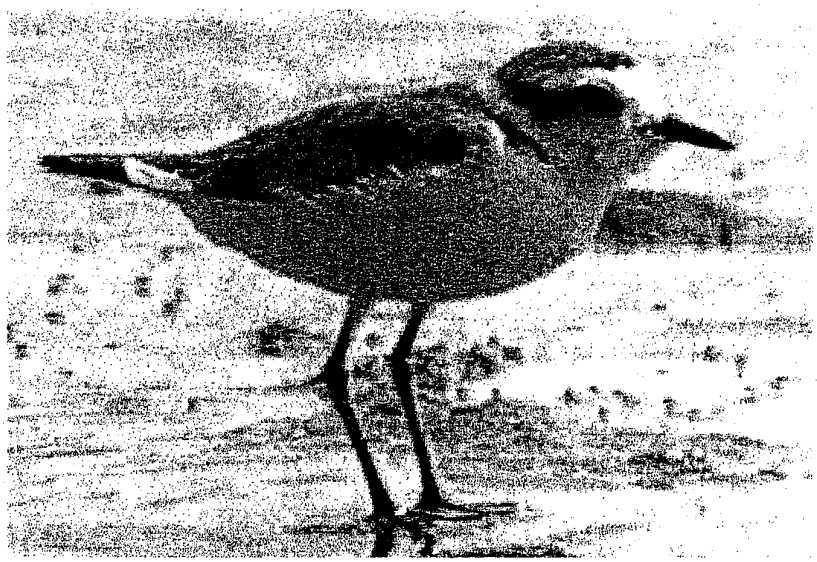
(415) 868 0371 ext 309 gpage@prbo.org

Sincerely,

Gary Page

Wetland Program Director
PRBO Conservation Sciences

Moss Landing Salt Ponds
Habitat Enhancement Plan



June 18, 2001

Prepared for:
California Department of Fish & Game
Region 3
20 Lower Ragsdale Drive, Suite 100,
Monterey, CA
93940

Prepared by:
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Western Regional Office
3074 Gold Canal Drive,
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95670

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J. JASPER LAMENT, PH.D.
REGIONAL BIOLOGIST
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3074 Gold Canal Drive
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LEADER IN WETLANDS CONSERVATION

Introduction

Moss Landing Wildlife Area comprises 872 acres of tidally influenced habitat in northern Monterey County. The Wildlife Area is located near the mouth of Elkhorn Slough at Moss Landing, CA. The Moss Landing salt ponds are a uniquely valuable component of this habitat, consisting of 153 acres of retired salt evaporation ponds. Highway 1 borders the ponds to the west, Elkhorn Slough to the south, Elkhorn Ranch (uplands) to the east and Bennett Slough to the north. Both Bennett and Elkhorn Sloughs are connected to Monterey Bay, the former by a culvert under Highway 1 and the latter by the Highway 1 Bridge.

The Department of Fish & Game (CDFG) purchased the ponds from Western Salt in 1984 for the purpose of maintaining shorebird and waterfowl habitat in the area. Prior to the purchase, the ponds had been inactive for a period of years, leading to a levee breach in 1982. The Point Reyes Bird Observatory (PRBO) assists CDFG by providing water management for the ponds.

The salt ponds are extremely important to the Monterey Bay breeding population of Snowy Plover. In 1999, 63% of the Snowy Plover young known to have fledged in the Monterey Bay region were produced in the salt ponds. The ponds have the highest hatching success (86% in 1999) and fledging success (1.91 chicks/male in 1999) in Monterey Bay. The ponds are the most productive Snowy Plover habitat in the Monterey Bay region.

Brown pelicans frequent the ponds and they have been observed roosting in the ponds, usually in shallow water (Doug George, PRBO, personal communication). In addition to these endangered species, the ponds provide various habitat functions for numerous shorebirds, seabirds and waterfowl. American avocets and black-necked stilts both nest on the levees and rear their young in the ponds.

Existing Conditions

The ponds were originally designed to operate in series. While this was suitable for commercial salt production, it poses difficulties in managing water for wildlife habitat. Water that is introduced into one pond must be raised higher than desired in order to push it into the next pond in line, and so on down the chain. This makes managing each pond at an optimal level for habitat production an impossible task. In addition, not having an independent source of water for each pond reduces water circulation and can result in poorer water quality in the ponds further down the chain.

CDFG constructed an exterior levee from dredge spoils in 1989, and half of the ponds were allowed to return to salt marsh. In the remaining salt ponds, CDFG installed new water control structures in 1991. Water is still brought in through an intake off Elkhorn Slough under the current system. This intake feeds a 2.7acre ditch that dissects Ponds B and D (Figure 1). Water from the intake ditch can be introduced directly into Ponds A, B,

C and D. There is no outlet for the ponds, however, and water that does not evaporate must exit the same water control structure that it entered. This limits circulation and can lead to stagnant water in the ponds.

The upper end of Pond C and Ponds E through I seldom, if ever, receive water under the current system. As a result they are being encroached upon by pickleweed. It is possible to push water back to the upper reaches of Pond C and into Pond F, but this would be done at the expense of habitat in the lower reaches of Pond C and Pond D, respectively. Even then it is unlikely that the water could be maintained at a level that would prevent pickleweed encroachment.

The pickleweed poses a problem in that it reduces the amount of mud flats available to the shorebirds and provides cover for predators. It also reduces the value of the substrate as nesting habitat for the Snowy Plover. A report written by PRBO staff indicates that the ability to independently flood up ponds for long durations in order to control the vegetation would be desirable (George 1997). This is impossible given the current pond configuration.

With the existing ground configuration, the water in the ponds is primarily located in the borrow ditches adjacent to the levees. This attracts shorebirds to these areas for foraging, closer to the vegetated levees and the terrestrial predators that use them. The levees also support annual grasses, which provide habitat for small mammals. The mammals attract raptors to the pond system; the raptors prey on both the mammals and Plover chicks.

Purpose

The management goal for the Moss Landing salt ponds is to provide foraging and breeding habitat for the Snowy Plover and other shorebirds, as well as roosting areas for brown pelicans and migratory waterfowl.

The goal of this proposal is to reconfigure the existing system so that the management goal can be met in a robust manner: one that would provide reliable habitat with a minimal amount of water manipulation and personnel commitment. The Moss Landing salt ponds are remotely located, with no staff on-site. Thus, it is crucial that the system be designed to function with minimal management.

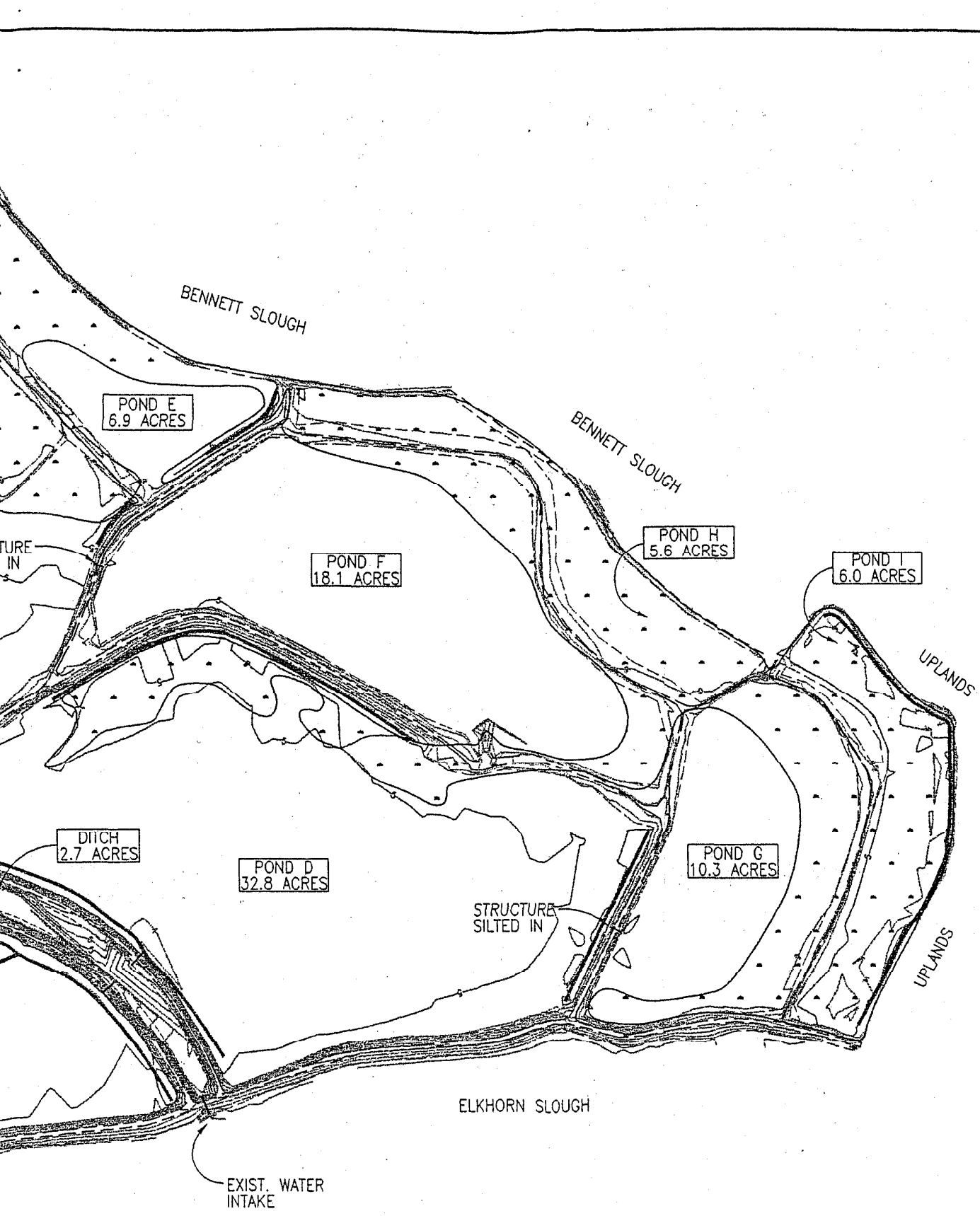
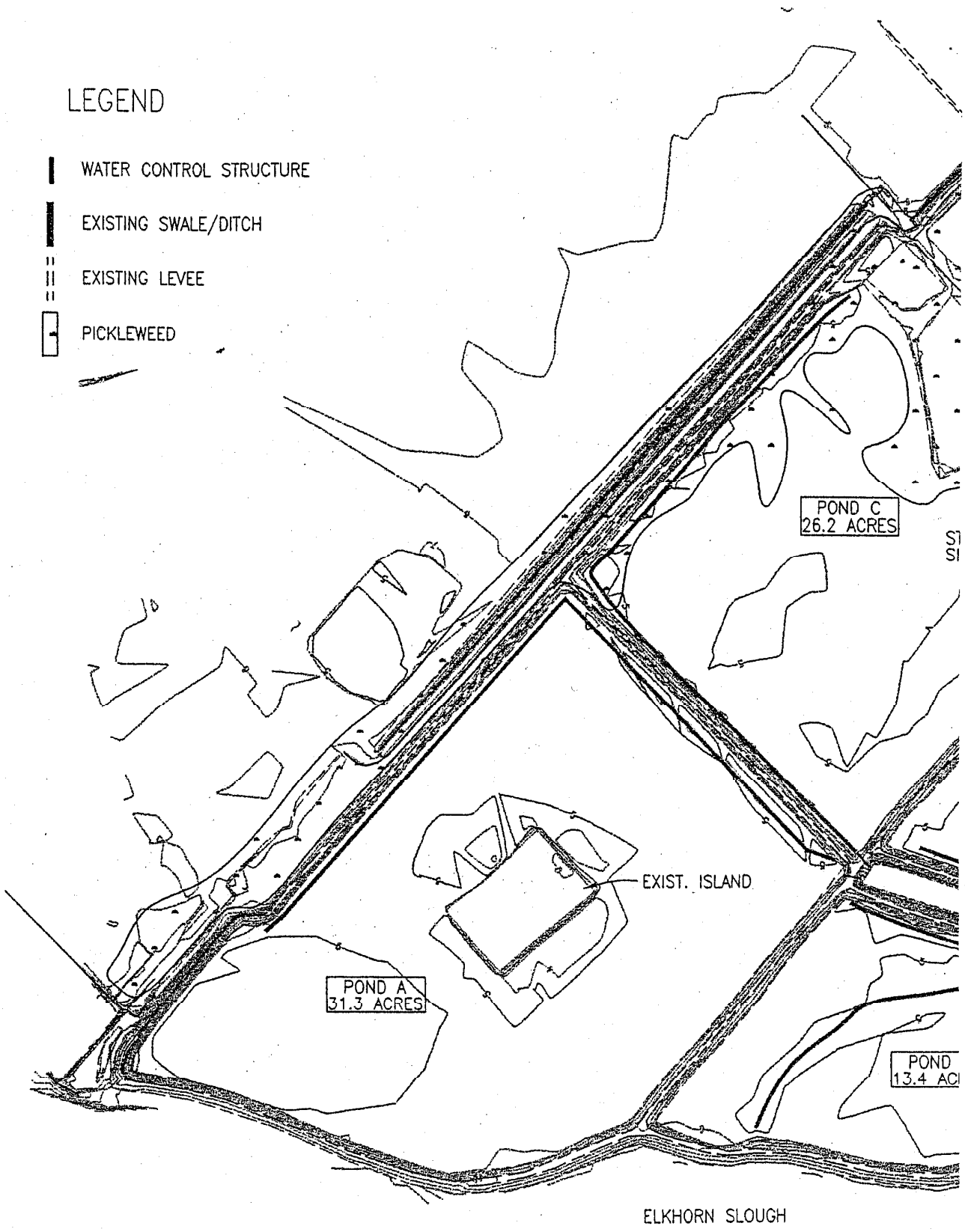


FIGURE 1

DUCKS UNLIMITED INC. WESTERN REGIONAL OFFICE	PROJECT NO. DU-CA-272-1		DESIGNED BY:
	MOSS LANDING SALT PONDS EXISTING CONDITIONS		DRAWN BY:
			SURVEYED BY:
			CHECKED BY:
DATE: 2/10/01	SHEET NO. 1 OF 1	APPROVED BY:	APPROVED BY:


LEGEND
WATER CONTROL STRUCTURE
EXISTING SWALE/DITCH
EXISTING LEVEE
PICKLEWEED
POND C
26.2 ACRES
EXIST. ISLAND
POND A
31.3 ACRES
POND
13.4 AC
ELKHORN SLOUGH

Design Challenges

The only source of water currently available to the salt ponds is a gravity fed tidal inlet off Elkhorn Slough. The average pond elevation is just over 5.0 feet North American Vertical Datum 1988 (NAVD88). Table 1 shows the correlation of tidal datum for Elkhorn Slough at Highway 1 bridge and NAVD88. The two datums are very closely correlated in this area. As Table 1 shows the mean higher high water (MHHW) is approximately the same elevation as the pond bottoms. Therefore, it is crucial that the intake structures be designed with sufficient capacity in order to capture the volume of water required for management during the high end of the tide cycle.

Table 1
Tide Elevations in Feet for Elkhorn Slough
Highway 1 Bridge, Moss Landing

Tide Stage	Tidal Datum*	NAVD88
MHHW	5.33	5.28
MHW	4.64	4.59
MTL	2.86	2.81
MLW	1.08	1.03
MLLW	0.00	-0.05

Notes:
1. NOS published data, publication date 5/19/1982
2. Tidal datum are based on the following:
   Length of Series = 4 months
   Time Period = June-July 1976, May-June 1977
   Tidal Epoch= 1960-1978
   Control Tide Station= Monterey (941 3450)

The installation of a pumping station is another possibility for providing adequate water supply to the system. This would allow water intake over a greater range of tides. Power lines border the project site and could be used to bring power to a pumping station. However, this would entail a greater capital expense and require reoccurring maintenance and power expenses. In addition, pumping stations are attractive nuisances and could potentially experience vandalism. Finally, pumping facilities require that personnel be on site to operate them. However, this investment is somewhat offset in that the manager would not have to wait until a higher tide to flood the ponds.

Vegetation is encroaching on the northern ponds in the system. Some of these ponds have been completely overtaken by pickleweed and provide zero Snowy Plover nesting habitat. The system must be designed in a manner that will allow independent flooding and holding of water for each pond in order to provide vegetation control without affecting the operation of the other ponds in the system.

Increased water levels will result in increased erosion of perimeter levees especially since high velocity winds are frequent in the area. PRBO has suggested that the pond levees be free of vegetation in order to eliminate predator habitat (vegetation provides habitat for

small mammals that attract raptors and terrestrial predators into the salt ponds). Vegetation is commonly used to resist wave erosion and the elimination of the vegetation will obviously predispose the levees to a higher rate of erosion.

High winds and fine material have resulted in the silting-in of westerly exposed water control structures (Figure 1). This obviously poses a problem to water management. The new system would have to be designed in a way that would reduce the tendency for silting-in of the water control structures.

PRBO manages the ponds for breeding shorebirds by trickling in small volumes of slough water to maintain low water levels and brine invertebrate populations. Water is transported and held in old borrow ditches, leaving most of the pond bottom dry in order to provide nest substrate for the Snowy Plovers. The borrow ditches provide foraging opportunities for the breeding pairs and their young. These ditches are adjacent to the levees, which brings the foraging birds closer to the levees, where they may be more susceptible to terrestrial predators. On the other hand, the absence of swales in the center of the ponds allows the chicks greater avenues of escape from avian predators (Doug George, PRBO, personal communication).

Recommendations

Ducks Unlimited Inc. (DU) has performed a preliminary design study for the Moss Landing salt ponds. The study considered many factors including but not limited to the issues presented above. Appendix A shows a preliminary design for the habitat improvements recommended under this proposal.

The primary need for the system is independent water control for each pond. Therefore, independent intake and drainage structures must be provided for each pond. As previously mentioned, both Elkhorn and Bennett Sloughs border the ponds. Bennett Slough is drastically muted by the culvert connecting it to Monterey Bay, and as such has lower high tide elevations than Elkhorn Slough. This can be capitalized upon by utilizing Bennett Slough as the drainage recipient for the system. The ponds would be able to drain into Bennett Slough even during high tides. Therefore it is logical to rearrange the ponds to allow water intake from Elkhorn Slough and water drainage into Bennett Slough.

Since Elkhorn Slough was identified as the water source for the ponds, the first step was to provide independent water supply to each pond from Elkhorn Slough. As previously mentioned the existing pond inverts are roughly at MHHW. Therefore it is essential that storage capacity be provided such that water volume captured during high tides is sufficient to meet the system's needs. The 2.7-acre intake ditch is currently the only reservoir for holding the high tide waters. The new configuration combines the intake ditch and Pond B to increase the storage capacity for the entire pond system. In this manner the capacity of the system is increased without altering the existing intake configuration in Elkhorn Slough. The new Pond 6 would be approximately 16 acres in size. The levee separating Pond B and the intake ditch would be breached at both ends,

limiting the amount of excavation required to accomplish the desired task and at the same time providing a nesting/roosting island.

Currently Ponds A through D are the only ones that have direct access to a water supply. Under this plan, Ponds C through H would be reconfigured in order to gain better water management capabilities (see Appendix A). This would result in the creation of Ponds 2, 3 and 4, each with an independent intake from Pond 6 and drainage into Bennett Slough. This configuration would allow the ponds to be placed on a rotational management system where any of the ponds could be managed for either shorebird habitat or flooded for pickleweed control without affecting the adjacent ponds. In addition, by reducing the number of ponds in the system the amount of levee is reduced. This is desirable because it simultaneously reduces the amount of upland habitat available to small mammals, and the number of corridors available to terrestrial predators.

Not only does the reconfiguration allow for better water control, but it also eliminates the siltation problems experienced with the current pond configuration. The existing structures connecting Pond C with Pond F and Pond D with Pond G (Figure 1) both have a western exposure and have silted-in due to the wind-generated waves. The new configuration would reduce the amount of fetch in the existing Ponds D and F by dissecting them with a levee and creating Ponds 3 and 4. The westerly exposed water control structures would be eliminated. All drainage structures face south, and are located in the northern edge of the ponds. This would limit the amount of siltation that the drainage structures experience since the primary sediment transport is in an easterly direction. The intake structures will be able to keep themselves clear through normal operation.

The intake structures will consist of combination gates. These gates allow the operator to bring water in on successive high tides and hold it during low tides without further manipulation. In this manner the water level can be ratcheted up over successive tide cycles to the desired elevation. The structures can be operated in reverse in order to drain the system into Elkhorn Slough on low tides, if so desired.

In addressing the issues of exposure to predators and foraging areas, DU suggests using small gravity fed water lines to deliver water to shallow ponds in the center of Ponds 2, 3 and 4. Water can be trickled in from the Pond 6 reservoir to maintain water levels and brine populations without restricting the movement of chicks. This also would increase the fringe area available to the shorebirds for foraging.

The drainage structures on Bennett Slough would provide better water management control by allowing the ponds to be maintained at the desired water depth while flushing slough water through the system. This would be accomplished through the use of flashboard risers, which can be set to spill excess water and maintain a desired elevation. Since the structures drain into Bennett Slough, the excess water can be spilled regardless of the tide cycle. This will maintain the desired water depth without the presence of an operator, eliminating the risk of overfilling the ponds. In addition, water will be passed through the system with each high tide cycle, greatly improving circulation. This will

improve the quality of habitat for wintering waterfowl and also give the operator the ability to keep pickeweed stands inundated.

Pond 5 is covered in pickleweed and is adjacent to neighboring uplands and trees. It's potential to provide shorebird habitat is negligible. Therefore, this pond will be managed as muted tidal wetlands by placing structures on Elkhorn Slough and Bennett Slough. This would allow the management of this pond for waterfowl habitat and hopefully provide a buffer between predators and the shorebird ponds.

The higher water levels in the ponds being managed for pickleweed control results in a higher potential for levee erosion. This can be protected against in several ways, including soil-cement treatment, rip rap, flattened and/or vegetated slopes and sacrificial berms. Rip rap obviously isn't desirable in this situation; neither are vegetated slopes due to the predator corridors they could create. Soil cement treatment would prevent erosion and initially prevent vegetation growth. Over time, however, any cracks that formed would allow the establishment of vegetation. It is also unknown how the soil cement would affect any potential habitat value of the levees themselves. It was decided that the windward levee slopes would be flattened to protect against erosion.

Finally, the buffer between Pond A (Pond 1) and Elkhorn Slough has been steadily eroding for some time. The integrity of this levee is essential to the protection of the salt pond system. This project would rebuild the slope utilizing on-site material and place slope protection rock to prevent any future erosion.

Overall this design will provide a high range of habitat diversity that can be manipulated with a minimal amount of personnel time. Each pond can be managed as a dry playa interspersed with brackish water ponds and swales (for breeding shorebirds), as a fully flooded pond (for pickleweed control), or as a muted tidal system (for wintering waterfowl and seabirds). Snowy plover breeding habitat will be immediately enhanced as well as protected in the long term.

Cost Estimate

This proposal is based on a preliminary design study performed by Ducks Unlimited. The study was funded by DU's MARSH (Matching Aid to Restore State's Habitat) program. In order to finalize the design, further hydrological, biological and engineering investigations need to be made in order to insure a design that would perform as indicated herein. It is estimated that a finalized design would cost approximately $30,000. The construction estimate for the preliminary design in this proposal is $750,000. This is assuming no major changes have to be made to the final design. A line item cost estimate for this proposal is provided in Appendix B.

Project Authorities

DU proposes to provide biological and engineering services to finalize the project design and provide construction management for this project. To complete this project we must

establish a cooperative agreement with the CDFG and secure funding sources for the activities mentioned herein. This cooperative agreement shall give DU authority to begin work on the project and allow access to the Moss Landing salt ponds for final survey and construction activities.

Literature Cited

George, D. 1997. Recommended actions to maintain and enhance wildlife values at the Moss Landing salt ponds. Unpublished report to California Department of Fish and Game, Region 3. 3 pages.

Page, G.W., Warriner, J.C., Warriner, J.S., Goerge, D., Neuman, K., Eyster, C., Dixon, D., Henkel, L., and Stenzel, L.E. 1999. Nesting of Snowy Plovers at Monterey Bay and Pocket Beaches of Northern Santa Cruz County, California in 1999. Point Reyes Bird Observatory, Stinson Beach. 15 pages.

Appendix B

Cost Estimate for Habitat Enhancement at the Moss Landing Salt Ponds

DU Project Number: US-CA-272-1
DU Project Name: Moss Landing
Created May 16, 2001

Phase I - Planning & Design

Line Item	Unit	Unit Price	Quantity	Extended	Total
Purchase WL recorder	EA	$2,500.00	2	$5,000	$5,000
Design Engineer					$10,720
Install WL recorders	HR	$67.00	24	$1,608	
Collect WL recorders	HR	$67.00	16	$1,072	
Evaluate Data	HR	$67.00	16	$1,072	
Adjust & finalize design	HR	$67.00	64	$4,288	
meetings(coop. & reg. agencies)	HR	$67.00	40	$2,680	
AutoCAD	HR	$55.00	32	$1,760	$1,760
Biologist					$4,288
Design input	HR	$67.00	32	$2,144	
meetings w/ cooperator	HR	$67.00	32	$2,144	
Travel & Meals	DY	$150.00	13	$1,950	$1,950
Sub Total					$23,718
Contingency	10%				$2,372
Sub Total					$26,090
Indirect Overhead	16.25%				$4,240
Phase I Total					**$30,329**

Phase II - Construction

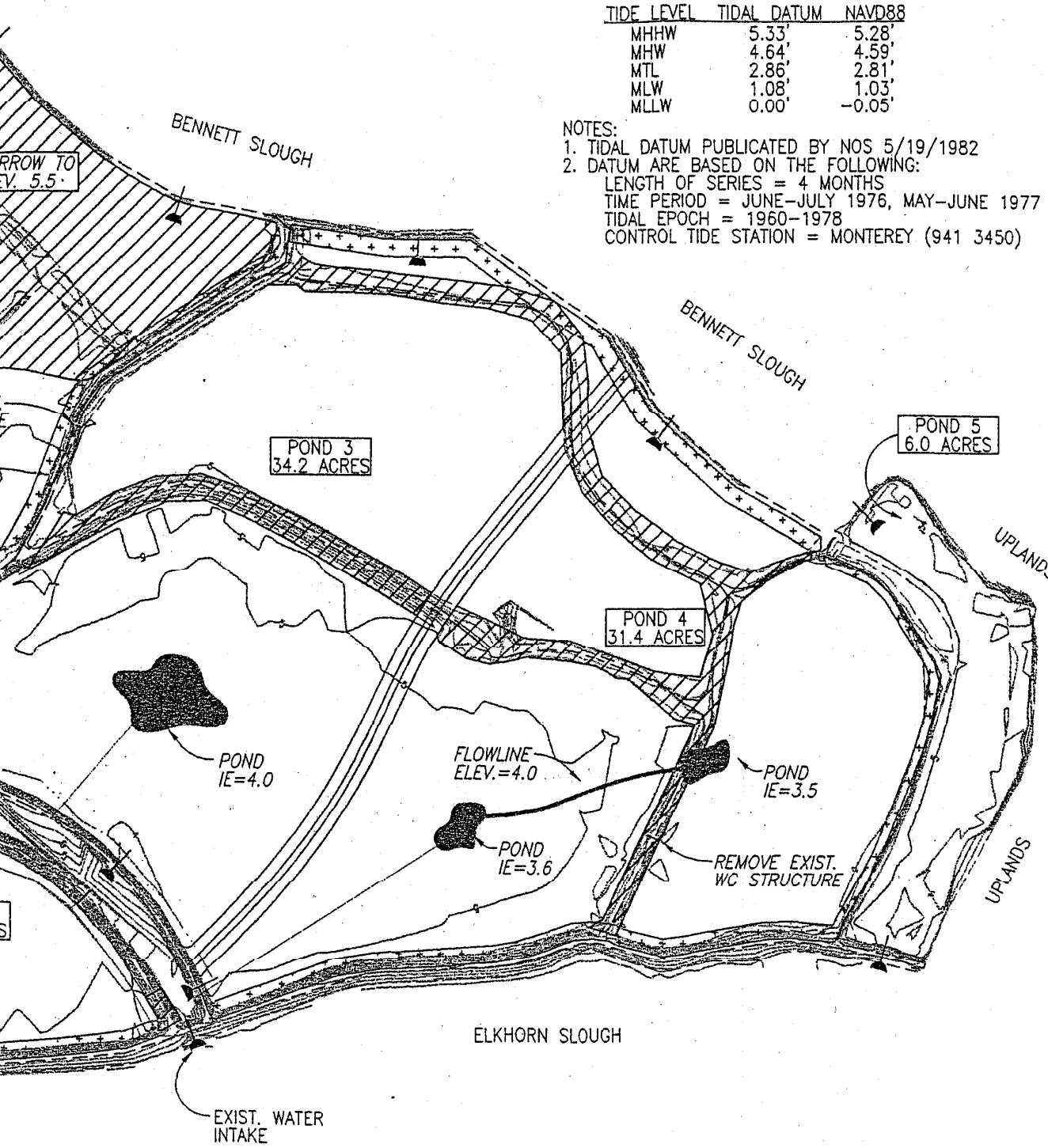
Line Item	Unit	Unit Price	Quantity	Extended	Total
Construction staking					$2,950
Surveyor	HR	$55.00	40	$2,200	
Travel & Meals	DY	$150.00	5	$750	
Construction					$477,087
Mobilization	LS	$43,371.50	1	$43,372	
Compacted Fill (in dry)	CY	$3.50	15500	$54,250	
Excavation	CY	$2.00	20500	$41,000	
Ditch cleaning	LF	$2.50	1530	$3,825	
Compacted Fill (Elkhorn Sl. Slope	CY	$10.00	5000	$50,000	
Rip Rap	CY	$70.00	1000	$70,000	
Canal Gate	EA	$5,000.00	4	$20,000	
Combination gate	EA	$8,000.00	6	$48,000	
Flashboard riser	EA	$2,000.00	5	$10,000	
Flap Gate	EA	$2,000.00	9	$18,000	
Culvert pipe	LF	$35.00	600	$21,000	
Install Water Control Structures	EA	$7,000.00	13	$91,000	
4" PVC pipe, risers and valves	LF	$4.00	1660	$6,640	
Sub Total					$480,037
Construction Inspection	10%				$48,004
Project Management	10%				$48,004
Contingency	15%				$72,005
Sub Total					$648,049
Indirect Overhead	16.25%				$105,308
Phase II Total					**$753,357**

APPENDIX A

TIDAL DATUMS AT ELKHORN SLOUGH
HIGHWAY 1 BRIDGE, MOSS LANDING

TIDE LEVEL	TIDAL DATUM	NAVD88
MHHW	5.33'	5.28'
MHW	4.64'	4.59'
MTL	2.86'	2.81'
MLW	1.08'	1.03'
MLLW	0.00'	-0.05'

NOTES:
1. TIDAL DATUM PUBLICATED BY NOS 5/19/1982
2. DATUM ARE BASED ON THE FOLLOWING:
   LENGTH OF SERIES = 4 MONTHS
   TIME PERIOD = JUNE-JULY 1976, MAY-JUNE 1977
   TIDAL EPOCH = 1960-1978
   CONTROL TIDE STATION = MONTEREY (941 3450)



PRELIMINARY

REVISIONS			
REV. NO.	DESCRIPTION	DATE	APPROVED
5			
4			
3			
2			
1			

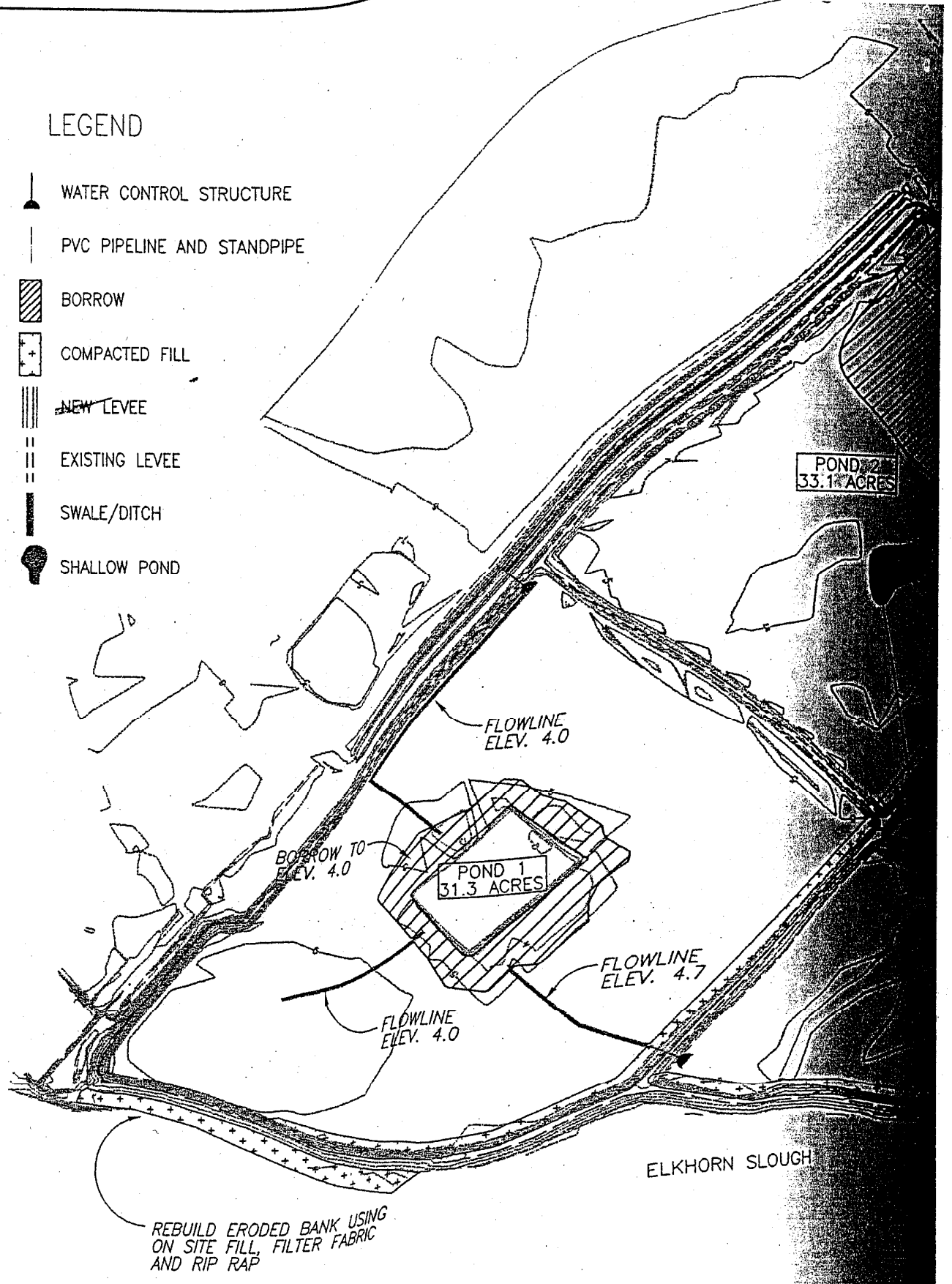
DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE

PROJECT NO. US-CA-272-1

MOSS LANDING SALT PONDS
HABITAT ENHANCEMENT

DESIGNED BY:	SC
DRAWN BY:	DU
SURVEYED BY:	DU
CHECKED BY:	

DATE: 2/13/01 | SHEET NO. 1 OF 1 | APPROVED BY: | APPROVED BY:



OTAGO

Te Whare Wānanga o Otāgo

17 January 2003.

Charlene Hall
U.S. Fish & Wildlife Service,
2800 Cottage Way,
Suite 2605, Sacramento,
CA 95825.

Dear Charlene

On behalf of the Rakiura Māori kaitiaki (environmental guardians) of the tītī I enclose:

1. A restoration proposal and request for funds from the *Command* oil spill trust monies to help repair the damage caused by the oil spill by eradication of rats from breeding islands
2. A video of the recent campaign to eradicate rats from Sub-Antarctic Campbell Island. We propose similar methods for the Rakiura Tītī Restoration Project and will use the same eradication team. It also illustrates the sort of video we hope to produce about our restoration project, albeit with a view to broadcast ours to world-wide television audiences (the tape is a rough cut for internal use only).
3. A report on the overall design of the Kia Mau Te Tītī Mo Ake Tonu Atu research project. It is for reference only (it explains more detail on the study methods and design than could be covered in the application for funds).
4. A complete set of the *Tītī Times*, the newsletter that we hope to use for education and raising the need for quarantine precautions after the rat eradication. A copy of the latest issue is embedded as Appendix B of the application, but the complete set is provided here for reference by the Trustee Council.

I have also sent separate copies of items 1 & 2 to the National Oceanic and Atmospheric Administration team (Ed Ueber, Jenifer Boyce & Kolleen Bannon) for their information.

Please direct all queries or requests for further information to me in the first instance. I will consult with the kaitiaki or Department of Conservation if need be.

Many thanks for considering our application.

Yours sincerely

Heinrik Moller

Dr Henrik Moller
Principal Investigator,
Kia Mau Te Tītī Mo Ake Tōnu Atu ("Keep the Tītī Forever') project.
Email: henrik.moller@stonebow.otago.ac.nz

Department of Zoology
Te Tari o Whakaaro Kararehe

PO Box 56, Dunedin, New Zealand.
Tel 64 3 479 7986 • Fax 64 3 479 7584 • Email zoology@otago.ac.nz
www.otago.ac.nz/zoology/

The Rakiura Tïtï Restoration Project:
Mitigation of the *Command* oil spill injury by eradication of rats from Sooty Shearwater breeding colonies in New Zealand

A request to the *Command* Trustee Council for funding assistance

By

Rakiura Tïtï Islands Administering Body
Kia Mau Te Tïtï Mo Ake Tönu Atu ("Keep the Tïtï Forever")
P.O. Box 743
Invercargill
New Zealand

Proposal prepared by:

[1]Dr. Henrik Moller, [2]Hannah M. Nevins, and [3]Josh Adams

[1]Zoology Department, University of Otago, P.O. Box 56, Dunedin, New Zealand

[2]Oikonos Ecosystem Knowledge, P.O. Box 979 Paradise Valley, Bolinas, California, 94924, USA

[3]P.O. Box 1103, Aptos, California, 95001, USA

January 2003

Kia Mau Te Tïtï Mo Ake Tönu Atu ("Keep the Tïtï Forever') project.
Email: henrik.møller@stonebow.otago.ac.nz

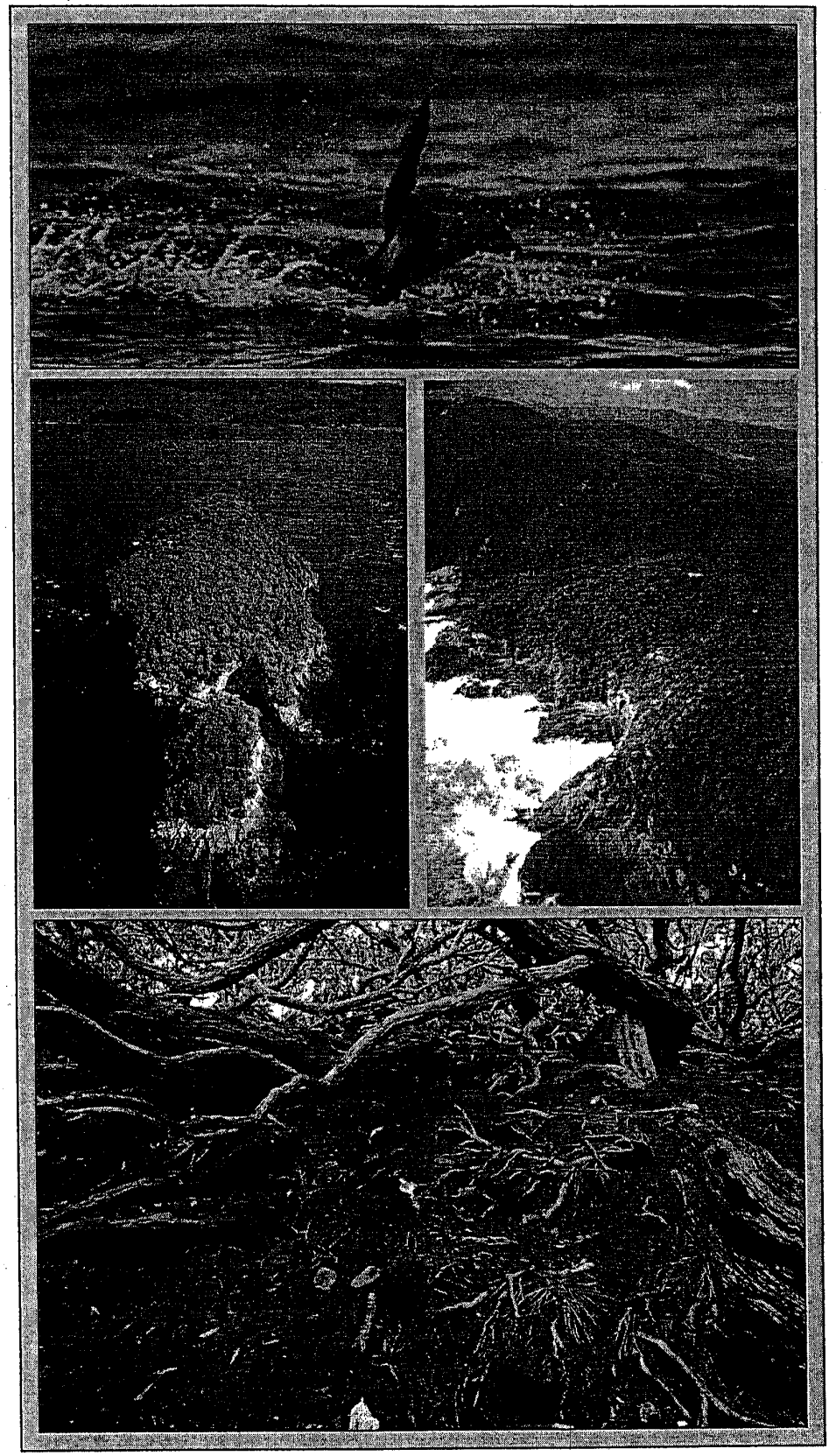
Frontispiece

Up to 30,000 adult sooty shearwaters may have been killed by the *Command* Oil spill in September 1998. The shearwaters ('Tïtï') are a treasured species of Mäori (New Zealand's indigenous people) and a keystone species on over 40 Nature Reserves in New Zealand. The 'kaitiaki' (environ mental guardians) of the tïtï request the help of the *Command* Trustee Council to repair the oil spill injury by eradicating rats from tïtï breeding colonies. (Photo: Tony Palliser)

Pukeweka is the smallest (2.5 ha) of four Tïtï breeding islands targeted for rat eradication. It is sandwiched between Taukihepa and Rerewhakaupoko Islands. Rats must be eliminated simultaneously from all nearby islands to prevent re-invasion by rats swimming between islands. The smaller Tïtï islands are entirely covered by breeding '*manu*' (burrowed ground) under a low *Olearia* forest. (Photo: Darren Scott)

Taukihepa ("Big South Cape") is the largest (929 ha) of all the Tïtï Islands and the main target for restoration through rat eradication. It is fringed by steep cliffs and so in many places is accessible only by helicopter. This is ancestral land of scores of *whänau* (birding families) that still continue their culture and livelihoods by a customary 6-10 week '*heke hao kai tïtï*' (harvesting expedition). This customary practice and cultural identity is threatened by global pollution and catastrophes like the

This photo shows the understory of a typical Tïtï breeding habitat ('*manu*'). Thick well-developed peaty soil is pitted with breeding burrows under a tangled 3 – 7 m forest canopy. Tïtï lay an egg within burrows that can be up to 5 m long. Tïtï abundance, breeding success and productivity is determined by counting entrance holes and determining burrow occupancy using an infra-red lit 'burrowscope' inserted down the burrows in search of eggs, chicks and breeding adults. (Photo: Melanie Massaro)



Executive Summary

The Rakiura Tïtï Restoration Project seeks to repair the injury to Sooty Shearwaters (*Puffinus griseus*) caused by the *T/V Command* oil spill in 1998 by eradication of introduced rats from breeding colonies on four southern islands of New Zealand. The project is spearheaded by Rakiura Mäori, New Zealand's most southerly group of indigenous people who manage this 'taonga' (treasured species) which they call 'tïtï'. The restoration team combines the Traditional Knowledge of the 'kaitiaki' (Mäori environmental stewards) with technical and scientific expertise of the New Zealand Department of Conservation, a University of Otago team of ecologists, and three United States environmental education and seabird experts.

Elimination of rat predation of eggs and chicks on Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui islands is the most reliable and rapid method of replacing about 20,000 tïtï estimated to be lost because of the *Command* oil spill. Rat eradication is proposed for mid 2004. Computer simulations emphasise uncertainty in outcomes, but most likely scenarios predict complete recovery of the oil spill injury within a year after rat eradication. However simulations using extremely pessimistic assumptions predict that complete recovery may take 4 decades. Long-term benefits to tïtï and several other species and conservation of ecosystem processes will result.

The Rakiura Tïtï Restoration Project team request US$ 538,000 from the *Command* Spill Trustee Council over the next 11 years to (i) eradicate the rats, (ii) establish quarantine to prevent re-introduction of rats, (iii) monitor and predict restoration success, and (iv) create educational outreach to inform the people of New Zealand and California about the project. Help in kind from other partners in the team is valued at about US$ 286,000, so the *Command* spill trust fund is being asked to contribute 65% of the overall project cost. The external contributions, together with savings from management and research efficiencies will make the project extremely cost-effective for the Trustee Council.

Rodent eradication would be by rapid aerial application of rodenticide (brodifacoum) from helicopters. Risks to humans and non-target species are considered minimal and will be reduced by best professional practice that restricts the total amount of toxin discharged, the time of application and the type of bait used.

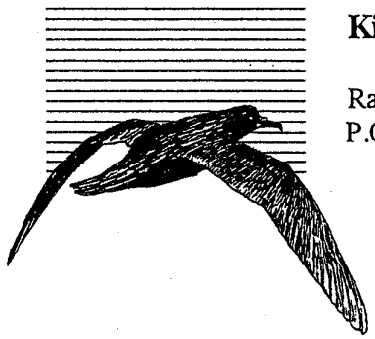
Intensive study of the rate of loss of tïtï eggs and chicks to rats, and comparisons of productivity before and after rat eradication, will allow computer simulation of rate of recovery of the *Command* oil spill injury in 2006. Longer-term monitoring of tïtï abundance at fixed study plots 8 and 9 years after eradication will then check model predictions and allow more definitive prediction of ongoing restoration outcomes.

A large number of Rakiura Mäori visit the islands each year and they transport considerable quantïtïes of food and gear from a variety of departure points. A concerted campaign to improve quarantine precautions will be instigated by this project. Rakiura Mäori scientists and managers will be employed to visit birders and urge care, to prepare posters and place poison bait stations at landing island sites. A Natural History television programme about the restoration project will be used to heighten community awareness and quarantine efforts.

The television documentary will be supplemented by CD-ROMS, interactive web-sites and a complete school educational package to educate Americans and New Zealanders about the project and need for environmental stewardship.

All methods for eradication, managing risks and monitoring outcomes have been proven and refined. Experienced and expert teams will secure the *Command* Trustee Council's investment in the restoration effort and make the operation safe. Recovery of the injury to tïtï is most likely to be rapid. Multiple long-term benefits to four island ecosystems and several non-target endemic species are certain additional outcomes. The Rakiura Tïtï Restoration Project promulgates a model for international and cross-cultural collaboration to mitigate the effects of a significant oil spill. Education effort will bring lasting benefits for conservation. The Rakiura Titi Restoration Project will build confidence that enlightened

research, management and litigation can combine to heal environmental injury resulting from negligence.



Kia Mau Te Tïtï Mo Ake Tönu Atu

Rakiura Tïtï Islands Administering Body
P.O. Box 743, Invercargill

Command Spill Trustee Council
California, USA.

22 November 2002.

Dear Trustees

Rakiura Mäori request your help to repair the damage done to our most treasured species, the tïtï (sooty shearwater), by the *Command* oil spill.

With your financial assistance we can eradicate rats from four tïtï breeding islands. The rats have been accidentally introduced and kill tïtï eggs and chicks. This is the best and fastest way that the reparation funds can replace the adult tïtï killed by the spill. It will bring a lasting benefit for our mokopuna (grandchildren).

The following plan has been prepared under our overall direction by Dr Henrik Moller, the principal investigator of our *Kia Mau Te Tïtï Mo Ake Tönu Atu* ("Keep the Tïtï Forever") research team. Dr Moller is an academic faculty member at the University of Otago whom we subcontract to conduct an ecological study to ensure that our harvests of tïtï chicks will be sustainable. He teaches and researches wildlife management (conservation, pest control and harvest management). We are also grateful to two Californian seabird biologists, Josh Adams and Hannah Nevins, for facilitating the preparation of this application and hope to involve them in the restoration program that comes out of this application.

Please direct any detailed questions concerning the science behind our proposal to Dr Moller at the Zoology Department, University of Otago, P.O. Box 56, Duned in, New Zealand (Telephone: + 64-3-4797991; Fax + 64-3 -4797584; Email henrik.moller@stonebow.otago.ac.nz). He will relay any necessary issues to us for guidance. All issues of overall direction, contracting and execution of the rat eradication and associated monitoring should be directed to the Rakiura Tïtï Islands Administering Body at the address above. We are the kaitiaki (environmental guardians) of the tïtï and their management.

Many thanks for considering our request.

Yours faithfully

Ron Bull
Kaiwhakahaere (Chairperson), Rakiura Tïtï Islands Administering Body

Mitigation of injury to Sooty Shearwaters by the *Command* Oil Spill

Goals and Nexus to Injury

The Rakiura Tïtï Restoration Project (RTRP) will directly replace or recover an equivalent to the estimated 15,591 tïtï (Sooty Shearwater, *Puffinus griseus*) killed during the 1998 *Command* Spill by eradicating rats from their breeding areas at the Big South Cape Islands group (Taukihepa, Pukeweka, and Rerewhakaupoko Islands) and Mokonui Island off Stewart Island (Rakiura), New Zealand.

The four main objectives of the RTRP are:

1. Eliminate rodents from four tïtï breeding islands, thereby eliminating egg and chick predation;
2. Establish quarantine contingencies to prevent reintroduction of rats to restored island colonies;
3. Monitor the restoration progress and project effectiveness;
4. Create educational outreach to inform the people of New Zealand and California about the Sooty Shearwater restoration project, and the cultural and environmental importance of the bird.

Damage to Sooty Shearwater caused by the Command oil spill

The majority of Sooty Shearwaters that occur off California during the austral winter migrate from New Zealand breeding colonies, where they are known as 'tïtï' by Mäori (New Zealand's Indigenous People). Sooty Shearwater is the most abundant seabird off central California during May to September[1]. They aggregate in large conspicuous flocks to feed on shoaling fishes, squid, and euphausiids that concentrate in productive shelf waters influenced by coastal upwelling[2]. Single flocks can extend for many kilometres and number in the

[1] Briggs *et al.* (1987).
[2] Briggs & Chu (1986).

10 – 100,000s. Their aggregated dispersion along the populated coast and near offshore shipping lanes makes shearwaters particularly vulnerable to oil pollution. Numbers off California have declined precipitously during the past decade due to a combination of factors, including marine climate change, incidental fisheries take, and pollution[3].

The T/V *Command* oil spill occurred on 26 September 1998, just prior to the migration of Sooty Shearwater back to southern hemisphere nesting colonies. Sooty Shearwaters were the second most frequent species among oiled birds recovered and were by far the most abundant species counted during aerial surveys within the spill area[4]. During spill recovery efforts, survey personnel recovered a dead, oiled Sooty Shearwater at Seaside Beach, Monterey County. This individual had been banded as it entered a nesting burrow the previous year on Whenua Hou Island, New Zealand. This confirms damage directly linked to the New Zealand shearwater population. This notable recovery along with 11 additional shearwaters recovered on beach surveys provides sufficient evidence that the *Command* Spill negatively impacted this trans-Pacific migrating seabird.

No mortality estimates were calculated for the Sooty Shearwater in the *Command* Trustees Bird Injury Report. We used similar methods as were applied to Common Murre by the Trustees to estimate Sooty Shearwater mortality. Our most probable estimates indicate that around 15,591 shearwaters were killed during the *Command* Spill[5]. Sooty Shearwater was therefore probably the most numerically affected species. Loss of production of chicks because of the death of their parents in the spill would mean that 20,265 fewer tïtï were in the population by the current (2002/03) breeding season because of the spill[6]. Furthermore, as this event occurred just prior to

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[3] Veit *et al.* (1996, 1997), Lyver *et al.* (1999), Uhlmann & Moller (2000), Oedekoven *et al.* (2001), Uhlmann (2001).

[4] 11 – 346 birds km^{-2} were reported by Boyce and Hampton (2002).

[5] Our estimate ranged from 1,489 – 29,606 (Appendix A).

[6] This calculation (Appendix A) is incorporates the median scenario for lost production from the 1998/99 to the 2002/03 breeding season and the natural wasting away of the missing adults had they not been killed by the spill. If rat eradication can be achieved in 2004, it will be 2011 before an increased number of adults triggered by rat eradication will enter the

mainland colonies[13]. Kiore[14] (*R. exulans*) were introduced to breeding islands by Mäori several centuries ago and black rat (*R. rattus*) during the 1960s. Whereas Norway rats (*R. norvegicus*) are destructive predators of tïtï on mainland colonies, and until recently on Campbell Island, the most widespread rat and the more serious threat to tïtï eggs and chicks is

[12] Campbell (1967), Towns *et al.* (1990), Hawke & Newman (2001).
[13] Hamilton & Moller (1995), Hamilton (1998), Lyver (2000), Jones (2000, 2001).
[14] Also known as the Polynesian rat, kimoa or Pacific rat.

In California, Sooty Shearwater is appreciated by thousands of coastal visitors each summer. The large, conspicuous feeding flocks in Monterey Bay and off Santa Cruz, and Halfmoon Bay focus attention on the unique habitat and importance of California coastal waters to seasonally migrating marine wildlife. Each year local Monterey Bay area newspapers cover the dramatic phenomenon of thousands of feeding shearwaters, further increasing public awareness of marine issues. Several local visitor destinations (*i.e.*, Seacliff Beach State Park) in the area feature educational displays involving aspects of the shearwater's occurrence, unusual historical events, and ecology in the Monterey Bay area. The Channel Islands National Marine Sanctuary has acknowledged the importance of shearwaters in the California Current by recently naming their new research vessel the R/V *Shearwater*.

Ecological Importance

Tïtï are a keystone species[10] on 36 islands around Rakiura[11] (Fig. 1), and on The Snares (a globally important sub-Antarctic nature reserve). Nest-site excavation and guano deposition enhance soil formation, aeration, nutrient-cycling, regeneration, and vegetation succession[12]. Any long-term decline in tïtï numbers will profoundly affect the ecology of more than 40 nesting islands through cascading bottom-up effects to indigenous plants, invertebrates, lizards, and terrestrial birds. Tïtï are therefore the most important species to protect in these island nature reserves.

Impact of Introduced Predators on Shearwaters

The most easily reversed detrimental impact to New Zealand tïtï breeding populations is predation by introduced predators. Rats (*Rattus spp.*), stoats (*Mustela erminea*), feral ferrets (*M. furo*) and feral house cats (*Felis catus*) were introduced 125–200 years ago and now kill both tïtï adults and chicks at

[10] This is a species that has a disproportionate effect on several other species in the ecological community (Paine 1994).
[11] Rakiura is the Mäori name for 'Stewart Island'.

the pre-breeding migration, adults exposed to a sub-lethal level of spilled oil may have suffered undocumented compromised reproductive output during the 1998/99 nesting season.

Cultural Importance of Sooty Shearwaters

The Rakiura Mäori, New Zealand's southern-most indigenous people, considers the tïtï (Sooty Shearwater) to be a '*Taonga*', a treasured species. The Ngäi Tahu Settlement Act (1987) established the Rakiura Mäori as *Kaitiaki* (environmental stewards) for this species and returned to them ownership and management rights of tïtï breeding islands[7]. The islands are covered in a low coastal forest under which the tïtï dig breeding burrows in a thick, peat soil (see Frontispiece). The annual journey to harvest chicks from the Tïtï Islands is a defining cultural activity that generates social cohesion and group identity amongst Rakiura Mäori. The Rakiura Mäori abide by strict traditional teaching and bylaws to regulate chick harvest and to protect the revered adult birds and their island breeding habitat. Maintaining the number of tïtï is paramount to safeguarding customary practices and Rakiura Mäori culture. The Rakiura Mäori community instigated a long-term research project called *Kia Mau Te Tïtï Mo Ake Tönu Atu* ("Keep the Tïtï Forever") to ensure that the tïtï remain plentiful for the *mokopuna* (grandchildren)[8]. The Rakiura Tïtï Islands Administering Body (RTIAB) is the executive group directing this research on behalf of the whole Rakiura Mäori community to assess the potential population level impacts of their chick harvests[9].

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breeding population. By then 23352 fewer tïtï would be in the population because of the oil spill.

[7] Moller *et al.* (2000) outlines the ways that the Ngäi Tahu Settlement Act (1987) designates taonga species and the way the Tïtï Islands where the sooty shearwaters breed must be managed as nature reserves while still allowing a sustainable harvest of chicks.

[8] You can read about research project goals and design on its website: http://www.otago.ac.nz/Zoology/tïtï/default.html. A review of the project's wider context of co-management and multicultural approaches is also given by Taiepa *et al.* (1997) and Moller *et al.* (2000).

[9] First predictions of harvest sustainability are due in 2007 (Moller, in press), but there are preliminary signs that any harvest impacts could not be a sufficient explanation for recent declines. There have been large-scale declines at both harvested and unharvested islands, even where unharvested islands are a long way from harvested ones. This separation makes it less likely that harvesting has triggered some of the decline at unharvested ones by reducing or cutting off sources of immigration. Nor could harvest impacts explain the correlations we have observed with El Nino climate oscillations and tïtï adult survival (Lyver & Moller 1999; Lyver *et al*, 1999).

Fig. 1. Location of the Titi Islands, the main breeding colonies of Sooty Shearwaters (*Puffinus griseus*). The banded sooty shearwater killed in the *Command* oil spill was breeding on Whenua Hou (Codfish Island). The four islands nominated for rat eradication are Taukihepa, Pukeweka, Rerewhakaupoko (the 'Big South Cape' group) and Mokonui.

posed by the black rat and the smaller kiore[15]. Rats probably kill some eggs but their main population impact is caused by predation of young chicks just after the 'guard stage' when both parents must leave the chick unattended in order to forage for themselves and their chick. Direct action to eliminate predation of tïtï by introduced rats at breeding colonies will provide the greatest and most certain return to tïtï populations and damaged island ecosystems.

Our proposal is in many ways similar to one currently underway in the United States of America, funded by the *American Trader* Trustee Council, where black rats are being eradicated on Anacapa Island, California. The National Park Service and Island Conservation Group along with the American Trader Trustee Council successfully implemented two phases aimed at removing introduced black rats from Anacapa Island through helicopter application of rodenticide (Brodifacoum)[16]. Rats were introduced to Anacapa over 100 years ago, and have affected vegetation, nesting seabirds, and the island ecosystem. The Anacapa Restoration Project is intended to enhance the seabird populations on the island, as a main goal of the American Trader Trustee Council, but also will serve to enhance the overall ecosystem. To fully evaluate the eradication effects, seabird monitoring was established on the island prior to the eradication, and will continue for up to 10 years following the removal of the rats.

Whereas Sooty Shearwater breed on both the New Zealand mainland and island sites, predator control on mainland colonies would bring only temporary relief because ubiquitous introduced predators would re-invade cleared areas every year. Also, predator control on the mainland will only restore small numbers of tïtï because the colonies have dwindled to only a few breeding pairs[17]. Eradication of introduced predators on the Tïtï Islands is a more efficient strategy, providing a permanent refuge with undisturbed breeding habitat for shearwaters and other native flora and fauna. The large, dense

[15] Kiore were once considered to be predominantly vegetarian, but more recent diet studies show it to be omnivorous (Atkinson & Moller 1990).
[16] American Trader Trustee Council Annual report 2001, Jan 2002, 4 pp.

breeding colonies around Rakiura offer the best, most feasible prospects for the *Command* Trustee Council to repair the injury to tïtï as quickly as possible.

Although there have been no formal studies of the impact of rats on tïtï abundance, accumulating evidence indicate negative effects of rat predation are occurring. Inferences indicating rat impacts include:

- Declines in seabird abundance and total elimination of some seabird breeding colonies have been well documented in New Zealand and other Pacific islands[18].
- Predation by introduced mammals has been identified as the most serious threat to New Zealand seabirds[19]. Norway rats, black rats, and kiore are listed as main threats, especially to the smaller seabirds. Continued eradication of rats from island breeding colonies is the main recommended conservation strategy. Rats impact Grey Petrel, Black Petrel, Cook's Petrels, Chatham Island Taiko, New Zealand Sooty Tern, and several non-threatened seabird species.
- Norway rats killed virtually every Sooty Shearwater chick on Campbell Island during a 1985/86 study[20].
- Breeding of tïtï in 1994/95 and 1995/96 totally failed at the Taiaroa Head Reserve colony where mustelids and feral house cats were virtually eliminated, but rats were abundant[21].
- Rats occur at very high densities on the Big South Cape Islands group considered in this proposal for eradication[22].
- Kiore were recently filmed taking Little Shearwater eggs and significantly affect their productivity[23].
- Kiore impact threatens Pycroft's Petrel productivity[24].

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[17] Hamilton *et al.* (1997), Jones (2001), Jones (in press).
[18] Atkinson *et al.* (1978), King (1990), Towns *et al.* (1990).
[19] Taylor (2000a & b).
[20] Taylor (1986) found rapid decline in burrow occupancy just after hatching (when non-guarding begins) and abundant sooty shearwater feathers and flesh in rat stomachs. No other predator existed on the island so it is certain that rats were responsible for wiping out over 95% of the annual productivity. Historical records show that sooty shearwaters were much more abundant on the Campbell Island mainland before rats were introduced.
[21] Lyver *et al.* (2000). The rats were not identified, but probably were *R norvegicus.*
[22] See comments by Tïtï Harvesters recorded at http://www.otago.ac.nz/Zoology/hui/Main/Talks2/Tane.htm
[23] Pierce (1995), Booth *et al.* (1996).

- Chick harvest rate declined sharply from 1970 to 1973 on Taukihepa (the main Big South Cape Island proposed for eradication) 6 to 9 years after the accidental introduction and irruption of *R. rattus*[25]. The timing of this decline coincides with when the 1964 and 1965 cohorts of eggs and chicks would have re-appeared for breeding if they had not been killed by rats. The tïtï research team is currently seeking additional chick harvest diaries to determine if similar perturbation in harvest rates occurred on Pukeweka and Rerewhakaupoko, compared with nearby rat-free islands[26].
- Rats irrupted at Kaihuka Island in 1990[27]. The species was not formally identified but probably was *R. rattus* as it predominates on the islands off the eastern flank of Rakiura. There was abundant sign of rat digging and scrapes that year (a characteristic feeding sign from rats digging for invertebrates). No formal measurements of impacts were taken, but it was obvious that there were hardly any chicks present that year. In contrast, there was an excellent harvest season on nearby, rat-free Breaksea Island and on other Tïtï Islands. Two muttonbirder '*whänau*' (families) abandoned harvesting on Kaihuka after only one week in 1990. The one family that stayed on caught very few birds. A concerted rat poisoning effort was made later that year and poison baits are now administered regularly, resulting in reduced rat sign. No other chick failure years apart from the '*kiaka*' (naturally occurring starvation years) have been recorded in the 25 years that Peter and Joyce Topi have harvested on Kaihuka.

The Rakiura Tïtï Restoration Project

International RTRP working group

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[24] Pierce (1995).
[25] Harvest rates are described by Moller (2002). Bell (1978) describes the detail of the rat irruption and impacts on several land birds and bats in particular.
[26] Without this replicated evidence we can not conclude for certain that the rats caused the perturbation observed on Taukihepa in 1970-1973.
[27] Peter Topi, pers. comm. (25 November 2002). Kaihuka is an islet off the eastern coast of Rakiura.

The Rakiura Tïtï Restoration Project (RTRP) preliminary working group includes members of the Rakiura Tïtï Islands Administering Body (RTIAB), Rakiura Tïtï Islands Committee (RTIC), New Zealand Department of Conservation (DoC), the *Kia Mau Te Tïtï Mo Ake Tönu Atu* ("Keep the Tïtï Forever") research team from the University of Otago, the United States-based non-profit research group *Oikonos*, and independent consultants from the United States. Support and ongoing collaboration with California researchers is envisaged to help guide the RTRP.

The RTIAB consists of 10 elected representatives of the Rakiura Mäori community. They consult with the Rakiura Mäori community of over 1000 people in annual '*hui*' (traditional gathering in a Mäori meeting house) and special meetings called to discuss issues such as the proposed rat eradication. In accordance with many indigenous people's societies around the world, decisions are taken by consensus after considerable community debate. The RTIAB is a statutory non-profit making body established under the Ngäi Tahu Settlement Act 1997. The Mäori custom is to conduct business '*konohi ki konohi*' (face-to-face), so members of the RTIAB request to meet the Trustee Council from time to time to speak to their proposal.

Another group within the Rakiura Mäori community that must be involved in the implementation of any rat eradication campaign is the Rakiura Tïtï Islands Committee (RTIC). This represents a group of "beneficial owners" and includes the whänau on Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui. Access to the islands is only possible with the beneficial owners' agreement. While the RTIAB direct the overall research and tïtï restoration initiative of which this rat eradication will become part, the RTIC will be involved in all decision making. There have already been extensive community discussions about rat eradication and the strong consensus is to proceed. More discussion of the details of project will follow if funds are found to enable eradication.

Both Hanna M Nevins and Josh Adams have been involved in public hearings for the *Command* Spill issues and will assist the Trustee Council by sitting on

a restoration review committee and by acting as liaisons between New Zealand efforts, the Trustees, and the general public in California. They would meet the RTIAB annually in the early years of the project and will provide the Trustees Council with information regarding the progress of the project by presenting results from the project. We are not aware of any potential problems should funding be allocated to the RTIAB for this project, but a US-based organisation such as *Oikonos* could serve as a recipient and foundation to fund work in New Zealand if the Trustees are not able to, or are unwilling to fund groups outside the USA.

Collaboration with Dr Richard Veit (CSI/CUNY, Staten Island, NY) and our research team has also been proposed. Dr Veit's survey work in the Californian current neatly complements our research on the tïtï breeding islands so we plan to work together, share data and combine analyses. Dr Veit's research is focussed on tïtï in the Californian current. Collaboration to understand tïtï population dynamics will help interpretation of monitoring results to measure the restoration success after rat eradication. Support of exchange visits between our teams will help to build international collaboration.

Selection of islands for rat eradication

The 'Big South Cape Islands' include Taukihepa (939 ha), Pukeweka (3 ha), and Rerewhakaupoko (30 ha) and are a natural choice for restoration via black rat eradication. Taukihepa is the single largest island where tïtï breed. The Big South Cape Island group is sufficiently far from the Rakiura mainland that rats could not re-invade naturally. Currently about 47% of the total area of Sooty Shearwater breeding ground in New Zealand is infested with rats[28]. Eradication of black rat from the Big South Cape Islands will more than halve the total rat infested breeding area and benefit the shearwater population dramatically. In addition to black rat eradication from the Big South Cape

[28] This calculation assumes that 45% of Taukihepa has '*manu*' (burrowed breeding grounds), ignores the very small mainland colonies, Solanders and Campbell Island colonies, but includes the Snares.

Islands, we also propose to eradicate kiore (*R. exulans*) from Mokonui (86 ha), the next largest island in the area with rats remaining. Successful eradication would leave only about 14% of the total New Zealand tïtï breeding area with rats.

Rats can swim at least 500 m. Therefore, our eradication campaign must eliminate every last rat from all islands in the vicinity. This means that rat eradication must occur simultaneously on all three of the Big South Cape islands – it would be a waste of money to do just one or two of the proposed islands. The isolated nature of the Mokonui (Fig. 1) precludes potential natural reinvasion. Eradication of kiore from Mokonui could be left undone if there were insufficient funds for the entire project. However, combining the Mokonui with Big South Cape islands operations allows significant cost-sharing and would be much more cost-effective than eradicating rats from each island separately. Efficiency gain results from taking full advantage of the assembled helicopter teams and equipment and trained personnel when at the remote southern islands. We urge the *Command* Trustee Council to allocate sufficient money to complete rodent eradication on all four islands to capture maximum cost efficiency.

Elimination of rodents from Big South Cape islands and Mokonui would leave rodent threats on smaller islands near the Rakiura mainland, some small near-shore islands in Fiordland[29], and dwindling colonies on mainland South Island[30]. Natural reinvasion of these islands following control makes them unsuitable for eradication attempts. Therefore, the *Command* Trustee Council will have taken all practicable and cost-effective steps available to replace the tïtï killed in the spill by funding the Big South Cape Islands and Mokonui eradications.

Eradication methods

[29] Fiordland is the southern western region of South Island, New Zealand.
[30] A full list of the Tïtï Islands and their rodent status is given in Moller *et al.* (1999). A copy of this report has been forwarded to the *Command* Spill Trustee Council with this application.

The RTRP will use "Pestoff"™ rodenticide[31] (20 ppm Brodifacoum). Cereal baits will be dyed green to minimise uptake of baits by birds as per Department of Conservation requirements. The bait has a field life equivalent to approximately 1-inch of rainfall. We plan two drops of baits using helicopters, the first at 8 kg/ha to be carried out on the first suitable forecast (predicting 3 fine nights) after an agreed date. The optimum time for the drop will be around 1st of July when rats are unlikely to be breeding and probably have the least natural foods available as alternatives to bait. The breeding shearwaters will be absent from the islands at this time. The second drop will be at 4 kg/ha[32], which will take place in the next suitable weather window at least 5 days after the first drop. This second drop is to ensure that there are no gaps in the bait coverage and to lengthen the time that rats have access to bait. The first drop will be done in strips with 50 % overlap between passes (*i.e.* 4 kg/ha coming out of the helicopter delivery bucket, sowing the 8 kg/ha on the ground). The second will involve 20% overlap. This strategy gives the proven quality standard required for total eradication, and minimises the amount of toxin introduced to the environment. On each drop, cliff areas will be flown twice to ensure sufficient bait is applied to these areas (*i.e.* 16 kg/ha over steep areas equates roughly to 8 kg/ha planar area).

These methods have been used successfully for other eradication projects in New Zealand including Whenua Hou (1900 ha), Kapiti Island (2200 ha) and Raoul Island (1300 ha). The first two operations were proven successful, and results are pending two more years post-drop before success can be established. If funded, the Big South Cape Islands RTRP will be the largest black rat eradication in New Zealand history.

Monitoring mitigation success and reporting outcomes

Sooty Shearwater population recovery is expected to be slow relative to other birds because shearwaters are long-lived[33], have low annual productivity[34]

[31] Manufactured by Animal Control Products Ltd., Wanganui, New Zealand.
[32] This can be increased to 8kg/ha if the first drop is washed out due to unpredicted rainfall.
[33] The oldest banded tïtï recovered so far was at least 37 years old (Newman 2001). Annual survival of breeding adults is 0.872 (S.E. = 0.035) (Scofield *et al.* 2001). In general seabirds

and do not begin breeding until about 7 years of age[35]. Hence we will need to evaluate restoration success using mathematical models and by measuring breeding success before and after rat eradication. Preliminary mathematical models of tïtï population dynamics have already been developed[36], so the simulations of the proposed rat eradication project will be rapid and cost-effective. The RTIAB hopes to continue to monitor population trends to independently validate model predictions. Therefore, we propose a long-term, intermittent monitoring of population trends for the decade following rat eradication.

Population monitoring before and after the application of rodenticide (experimental 'impact') will provide data to evaluate the effectiveness of this project and determine the recovery time for these tïtï colonies. We propose 'before' and 'after' monitoring data (burrow occupancy, hatching success, chick survival, and breeding success) during 3-5 years of intensive monitoring on the Big South Cape islands and Mokonui (impact sites) and islands with and without rats (control sites). The impact to breeding after eradication will be assessed using a before-after control–impact paired design[37] and mathematical modelling using measures of egg and chick losses to rats. A thorough survey of the area of Taukihepa covered in manu (breeding ground) and the proportion of it birded will be needed to improve model predictions. A major report will follow the main rat eradication effort and computer simulation of expected recovery of the spill injury. First reliable indications of the return for investment will be available for the *Command* Trustees in late 2005.

Predicted recovery will then be tested by repeated monitoring of fixed plots on impact and control sites 8 and 9 years after eradication (2012 & 2013), by which time the extra fledglings triggered by the RTRP will have been recruited to the breeding population. This external validation of the computer models

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are long-lived, slowly reproducing and have delayed maturation so that population turnover and recovery from perturbations is very slow (Croxall 1984, Croxall & Gaston 1988).

[34] Only one egg is laid per year, can not be replaced if lost and about a third of adults skip breeding each year.

[35] Richdale (1963).

[36] Hamilton & Moller (1995), Hunter *et al.* (2000a), Yearsley & Fletcher (2002, in press), Jones (in press).

will then allow more detailed and reliable long-term projection of restoration success.

The RTIAB seek to establish and develop their own scientific monitoring capacity to allow better future management and conservation for tïtï. An important first task will be to establish base-line plots[38] on Taukihepa, and Rerewhakaupoko to measure changes in tïtï egg and chick productivity before and after rat eradication. The *Kia Mau Te Tïtï Mo Ake Tönu Atu* research team has already established plots on Pukeweka and some monitoring plots in the southern end of Taukihepa[39], but more will be needed at the northern end of Taukihepa[40] and on Rerewhakaupoko and Mokonui[41]. It is imperative that such plots are established as soon as possible to get 'before' rat eradication measures of chick density. An extensive suite of 'non-treatment' (control) plots have already been established[42] on other islands where rats are present, and will not be eradicated, and on islands where rats have never been present. Some of the earlier plots will have to be rapidly re-surveyed at about the time of eradication to benchmark measurements to the time of the RTRP's experimental impact. Funds allocated by the *Command* Trustee Council will be used to employ a Rakiura Mäori science team, so that these plots can be re-assessed to better determine the effect of rat eradication on tïtï productivity[43]. However, additional new study sites with inspection hatches

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[37] BACI; Stewart-Oaten *et al.* (1986)

[38] Fixed transects have been established where the number of breeding burrows and their occupancy can be re-measured to monitor population and productivity changes (Moller *et al.* 1999). A miniature camera and infra-red lights mounted on the end of a tube inserted down the burrows is used to assess occupancy and breeding success (Hamilton *et al.* 1998, Lyver *et al.* 1998).

[39] Newman *et al.* (2002 a, c & d); Scott *et al.* (2002 a & d).

[40] The Traditional Environmental Knowledge of the tïtï harvesters emphasises how much the tïtï ecology varies from one 'manu' (breeding ground) to another (Lyver 2000, 2002), so large numbers of placed in a stratefied random way will be needed for robust statistical estimates.

[41] Owners have complete discretion about whether or not a science team visits their manu. Therefore the research team can not categorically promise that access will be granted. However, growing trust between the tïtï harvesters and research team has allowed several recent visits to new islands and there is no reason to suspect that the whänau will not accept the extension of sampling in the way now needed for evaluation of rat eradication. If access is prohibited, we will have to rely entirely on comparisons of breeding success on rat-infested islands that are Crown-owned Nature reserves (eg. Bench Island and some of the Fiordland National Park islands with tïtï).

[42] Moller *et al.* (2002 a & b), Newman *et al.* (2002 b & d), Scott *et al.* (2002 b & c).

[43] The University field research team is due to finish its field research in 2005. Thereafter ongoing monitoring will have to be by Rakiura Mäori's own science unit. The University team

over nesting chambers[44] will also have to be established on rat-infested islands (impact and control sites) to measure rat predation.

The RTIAB is presently working with the community to formulate a community monitoring plan and to test methods. A subgroup of the RTIAB was appointed in August 2002 to work with the research team to investigate ways of building their own scientific monitoring capacity and the immediate critical step was the funding question. A contribution from the *Command* Trustee Council would be a superb start and be extraordinarily well-timed just now to allow employment of Rakiura Mäori scientists to co-ordinate training and capacity building.

Locking in benefits: a public education campaign

Long-term benefits of rat eradication are critically dependent on establishing effective quarantine measures amongst the Rakiura Mäori tïtï harvesters and other visitors to the Big South Cape Islands. If pessimistic scenarios apply for the tïtï restoration rate, complete replacement of the injured tïtï could take decades[45]. Investment by the *Command* Trustee Council in public education about effective quarantine measures could therefore determine the difference between partial and complete restoration of the injured resource.

The RTRP will establish quarantine measures to be maintained by the RTIAB, thus ensuring long-term viability of the eradication. Similar programs have been established on the Pribilof Islands, Alaska by State and Federal agencies in co-operation with the Tribal Government of the Pribilof Islands and the native Tanadgusix Corporation. They work and plan together to protect these important seabird colonies from potential "rat spills"[46]. These

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has agreed to train young Rakiura Mäori scientists as they build their own capacity to take over the work. (Moller *et al.* 2000, Moller 2001).

[44] Described by Hunter *et al.* (2000b).

[45] See Appendix A for the basis of this calculation. At worst, full restoration could be achieved in 2039 if rat eradication is achieved in 2004, but much more rapid repair of the injury is likely.

[46] See website: http://www.akrrt.org/AIPlan/WPG_Pribs_April2002.pdf

well-planned programs provide a model framework for similar effective measures to be imposed by the RTRP.

The harvesters carry considerable quantities of gear and food supplies to the Tïtï Islands, so effective management and educational outreach is essential to prevent re-introduction by rodent 'stowaways'. We request funds to mount an intensive public education campaign amongst the birding community to safeguard the investment of the *Command* Trustee Council in rat eradication.

Our public education and rat spill prevention campaign will use:

- A special issue of the harvesters' newsletter, *Tïtï Times,* dedicated entirely to rodent (and insect and seed) quarantine precautions
- Regular articles in *Tïtï Times* on the need for rodent quarantine
- A natural history documentary will be produced about the project and distributed to birding whänau
- Posters at '*marae*'[47] and at vessel transport facilities emphasising the importance for vigilant quarantine
- Establishment of a web-based and paper-based media that outlines the threat of rats to islands, effective quarantine measures, contingency plans in the event of potential spills, and a list of contact personnel and their specific roll in responding to a potential rat spill
- Provision of rodent poison bait stations and poisons (i.e., rat spill kits) at main departure points on the mainland and main landing sites on the islands
- Employment of part of the science monitoring team to visit the *whänau* before each harvest season to ask them to take added care to ensure strict quarantine measures are established before travel to the islands. Similar briefings also will be developed for scientific and monitoring personnel.

Tïtï Times is an ideal platform to heighten the harvesters' awareness of the need for quarantine effort. It is a biennial newsletter sent free of charge to

about 500 harvesting families and another 400 policy makers, researchers, and stakeholders. A copy of the latest issue (No 11, Novemeber 2002) is reproduced at Appendix B of this proposal. A complete set of the newsletters has been sent to the Trustee Council for reference. The kaitiaki and research team have spent a considerable time and energy in building up a mailing list and servicing the production of this newsletter. We know it to be well-read and eagerly awaited by most of the harvesting community. The normal series of *Tïtï Times* is funded by a New Zealand government 'Public Good Science Fund' research grant to Rakiura Mäori. Such funding can probably be maintained until 2006. Our request to the *Command* Trustee Council is to immediately fund an additional special issue entirely on the quarantine issues and then to take over part of the production costs[48] of the remaining *Tïtï Times*.

Personal outreach to harvesters is an essential component to best ensure strict quarantine procedures are followed. Extension of the science monitoring staff responsibilities to include educational visits to families and communities before they depart to the islands is therefore needed.

International Education and Outreach

Education about the *Command* oil spill and the restoration of tïtï breeding colonies from rat eradication will help the public understand the vulnerability of shared natural resources in United States waters and abroad. The RTRP will develop natural history television, radio programs, and educational materials that describe seabirds and island ecosystems, their vulnerability to disturbance and restoration activities.

The inadvertent introduction of rats to the Big South Cape Islands in 1964 and resulting faunal extinctions were recognised as a national and international

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[47] Marae are traditional Mäori community meeting houses and community centres for learning.

[48] A fifth of the production and circulation costs would need to be levied to allow the rodent quarantine issues to be kept in the minds of the readers.

tragedy that underscored the devastating effects of rats on New Zealand's ecological communities. A large flightless beetle, three endemic land birds, and the world's most unusual bat (the Greater short-tailed bat, *Mystacina robusta*)[49] went extinct. Analogous to the infamous 1969 Santa Barbara Oil Spill in California, this single catastrophe galvanised conservation concern and action like no other event in New Zealand history. Both ecological disasters have increased public awareness about ecosystem damage and resulted in new environmental policies.

The RTRP will receive great public support in New Zealand, extensive media coverage, and further promote nation-wide environmental awareness. In addition, a documentary film will greatly assist in building motivation for increased quarantine precautions in New Zealand and USA alike. The kaitiaki and *Kia Mau Te Titi Mo Ake Tonu Atu* research team will facilitate community discussion and decision-making about the preparation of a professional documentary. The entire story (spill and climate change impacts, legal action, reparations, rat eradication, and ecological restoration) will assist public education about environmental threats and their management. Our preliminary budget request to the *Command* Trustees includes provision of USA$10,000 to make a documentary film using students of the postgraduate Diploma in Natural History Filmaking & Communication (Pg Dipl. NHFM&C) at the University of Otago[50]. An alternative would be to contract a private filmmaking team[51] to make a full-length natural history film for international distribution[52].

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[49] Bell (1978), Ramsay (1978).

[50] See http://www.otago.ac.nz/Zoology/naturalhistory/index.html for a description of this course. Negotiations are underway at the moment for films produced by the Pg Dipl. NHFM&C classes to be distributed by National Geographic.

[51] Peter and Judy Morrin have already gathered film of the Campbell Island rat eradication and are potentially keen to combine it with new material from this project. A rough 'educational cut' for internal use about the Campbell Island rat eradication has been forwarded to the *Command* Trustee Council along with this proposal. If funds allow, Peter and Judy Morrin would be keen to prepare a parallel or combined film on the two restoration projects.

[52] Budget allocation for the film will have to be adjusted once detailed negotiations are possible, but the USA$10,000 will definitely secure a Pg Dipl. NHFM&C production (it will meet helicopter and equipment costs).

A parallel public outreach campaign in California via educational materials distributed to State Park visitor centres, local TV and radio stations, and an interactive, informational website, will help educate people in California that shearwaters are an important cultural, environmental, and economic (e.g. ecotourism, bird-watching) resource throughout the Pacific. This joint US-NZ effort will also serve as a model for future international restoration efforts for migratory species that are affected by oil pollution.

The RTRP will develop a grade k-12 Seabird Ecology- Marine Science Curriculum educational package designed to meet California Educational Standards for Science. Products will include a seabird slide show presentation on CD-ROM to be made available via an interactive website, and quantitative lab exercise worksheets based upon the RTRP[53]. These materials will be designed for use in both US and New Zealand schools. Such a program would further increase cross-cultural understanding of a shared resource.

Suitability of this proposal for meeting *Command* Trustee Council's Selection Criteria

Nexus to Injured Resources

The Trustee Scoping Document and Bird Injury Report[54] did not provide an estimate of the total number of tïtï killed. We have therefore improvised by using the methods for estimating injury to Common Murre as outlined in the Bird Injury Report[55]. We conservatively estimate that 15,591 (range = 1,489 – 29,606) shearwaters were killed (Table 1; see Appendix A for the details of the calculations). We then used a simple computer simulation to estimate the size of the injury in successive years after the spill, allowing for natural wastage that would have occurred had the killed tïtï survived and allowing for

[53] Ms Nevins has already successfully put together an education package for local high schools (9-12 grades), based on her thesis data and marine mammal studies in Monterey Bay.
[54] Boyce and Hampton (2002)
[55] Ford (2002).

lost production of the chicks they would otherwise have fledged. By the time of the proposed rat eradication (2004), the most likely injury level will have escalated to 20,820 because of this lost production from killed tïtï (Table 1; Fig. 2).

'Pessimistic', 'median' and 'optimistic' rates of replacement of the tïtï by rat eradication were then simulated. Optimistic scenarios used plausible maximum estimates of (i) tïtï productivity, (ii) survival rate, (iii) chick density (iv) area of breeding ground on Taukihepa, (v) proportion of chicks remaining unharvested and (vi) current egg/chick predation rates (i.e. losses if no eradication is attempted). Pessimistic simulations used plausible minimum estimates for these parameters.

Pessimistic and optimistic scenarios provide extreme outer bounds for rate of recovery because they string several extreme parameter estimates together. The real-life parameters will be a mix of high and low estimates. Accordingly the median scenario is by far the most likely outcome. Nevertheless we can not categorically exclude the possibility that the outer upper and lower bounds apply until more field research is completed. We have also made several simplifying assumptions (Appendix A), so our projection models must only be used for approximate, order-of-magnitude predictions.

The wide range between 'pessimistic', 'median' and 'optimistic' scenarios (Fig. 2) reflect uncertainty in the population parameters, but the main determinant of the outcome is how many eggs and chicks are currently killed by rats (predation rate).

The worst-case scenario (pessimistic recovery model and pessimistic injury level) predicts that 14% of the tïtï lost from the oil spill will be replaced already within the first breeding season (2004/05) after eradication (Table 1). There will be complete replacement of the median injury level by 2013 even if pessimistic recovery rates apply (Fig. 2). If the pessimistic rate of recovery applies, complete replacement of the pessimistic injury level will not occur till 2039, 42 years after the spill.

The best-case scenario (optimistic recovery model and optimistic injury level) predicts that 362 times more extra tïtï will be generated by the rat eradication than died in the spill already one year after rat eradication (Table 1).

The most plausible (median) scenario also predicts that sufficient extra chicks will be fledged within a single year after eradication to replace all of the birds killed by the *Command* oil spill, no matter which scenario is used to estimate the size of the injury (Fig. 2). The indications are therefore very encouraging for the *Command* Trustee Council. It is most likely that their investment in rat eradication can immediately replace all the lost tïtï and then go on to restore the injury many times over provided that the islands remain rat-free for decades to come.

Feasibility

The rodent eradication project methods we propose have been proven to be effective against rats on islands throughout the world. Our proposed sampling to monitor mitigation effects have been developed and tested during the past 8 years by the *Kia Mau Te Tïtï Mo Ake Tönu Atu* research team. Furthermore, the infrastructure to conduct our public education campaign is already in place.

Table 1. Number of tïtï killed and subsequently missing because of the *Command* oil spill and the number recovered by rat eradication from Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui. Basis for the calculations is given in Appendix A.

	Pessimistic	Median	Optimistic
Injury from oil spill (1998)	29,606	15,591	1,489
Projected number of tïtï missing from population at time of rat eradication (2004)	34,931	20,820	2,417
% predation by rats	1%	5%	10%

Extra fledglings each year for first 6 years after rat eradication	5497	51,858	175,335
% Replacement of injured birds after 1st breeding season following rat eradication	14%	249%	8818%
% Replacement of injured birds after 10th breeding season following rat eradication	56%	924%	36197%

Fig. 2. Number of tïtï lost because of the *Command* oil spill and the expected number of replacements generated by eradicating rats from Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui according to optimistic, median and

pessimistic assumptions. The median scenarios (long dashes) are by far the more likely outcomes. See Appendix A for basis of simulations.

Legality

Proposed actions are all fully legal provided the statutory processes for Environmental Impact Assessment and resource consents are followed (see *Public Health & Safety* and *Likelihood of Adverse Impacts* below). The New Zealand Department of Conservation and RTIAB *kaitiaki* guiding the overall project will handle all statutory requirements.

Aerial broadcast of rodenticide requires resource consent from the Southland Regional Council. The working group will apply for consent[56]. Similar to the United States legal process, consent requires an Environmental Impact Assessment. The project will be publicly announced and any individual or group interested has the opportunity to submit formal comment on the proposed eradication. The council will consider all objections before aerial dispersal of rodenticide. There is then the opportunity for either party to appeal the decision to the New Zealand Environment Court. The *Kia Mau Te Tïtï Mo Ake Tönu Atu* research team on behalf of the RTRP will make submissions to this process to facilitate permitting[57].

Likelihood of success

World-wide, in the course of more than 100 island rodent eradication attempts, there have been no cases of failure where proven methods were applied with appropriate care and planning[58]. There can never be an absolute guarantee of success, but the experience of the New Zealand team is second to none in the world. The same team that would direct the eradication project described here has just completed the largest and most hazardous rodent

[56] This group will at least include the Rakiura Tïtï Islands Administering Body, the Rakiura Tïtï Islands Committee, the New Zealand Department of Conservation and the *Kia Mau Te Tïtï Mo Ake Tönu Atu* research team. The *Command* Spill Trustees Council could be formally associated with the application and process if it so chooses, or it could leave all responsibility with the local groups.

[57] There is little chance that the eradication attempt would be prevented, but rising (and at times irrational) public concerns about any use of aerial application of poisons make it paramount that a thorough and professional risk assessment is completed. Once the likelihood of net conservation benefit is understood, most New Zealanders support poison applications. A vigorous education campaign must accompany all proposals.

[58] C.R. Veitch (in litt. 26 November 2002).

eradication program yet attempted – to rid the sub Antarctic Campbell Island of Norway rats. Campbell Island is more than ten times the size of the combined islands targeted in this proposal[59] and much more remote. Proof of eradication success at Campbell Island will not be available for 2 more years, but preliminary signs are encouraging[60].

Even in the extremely unlikely event that complete eradication of rats fails, the density of rats will be suppressed to near zero for at least 3 years[61]. Median and optimistic scenarios suggest that even this initial knockdown will be sufficient to completely repair the oil spill injury. The *Command* Trustee Council can therefore be reasonably confident that the oil spill injury will be mitigated irrespective of whether the ultimate goal of complete eradication is achieved or not.

Cost Effectiveness

The current US$ to $NZ exchange rate will make this a highly cost effective project. The experience of the Department of Conservation management teams and associated helicopter pilots in similar island rodent eradication campaigns allows maximum efficiency. GPS guidance systems are used to ensure even coverage of bait application to minimise waste and toxin discharge while ensuring that no gaps are left that could harbour surviving rats. From the *Command* Trustees Council's point of view, the investment is extremely cost effective because they need not pay for the main time and experience of the Department of Conservation management team guiding the eradication[62]. A letter of support for the Tïtï Island Restoration Project and promise of technical support is at Appendix D. All statutory requirements will be handled by DoC and a voluntary group of kaitiaki guiding the overall project including the *Kia Mau Te Tïtï Mo Ake Tönu Atu* research team. Furthermore,

[59] Campbell Island is 11,200 ha, whereas the four Tïtï Islands considered here for rat eradication have a combined area of 1058 ha.
[60] P. McClelland pers. comm.
[61] The Department of Conservation waits 2 - 3 years after an eradication attempt to test for success, because it would take at least that long for any few survivors to multiply sufficiently to become detectable again. In the case of the Big South Cape islands, more than 3 years may be needed for reinstatement of any population because the islands are very large.

the cost of monitoring the outcomes for the tïtï from the Trustee Council's investment is a fraction of what would have been required had this initiative not been attached to an existing research project by the University of Otago team with established protocols for monitoring tïtï on other islands. Equipment and trained personnel are available to monitor outcomes and report them. Comparative data from non-treatment areas (where rats have not been eradicated) can be contributed without accruing much extra expense, although some rapid re-surveying of marked plots is forced by the need to monitor restoration from rat eradication.

Multiple Resources Benefits

The RTRP will benefit multiple island ecosystems including the terrestrial faunal community, as well as restoring the oil spill injury to tïtï. Introduced rats have probably altered regeneration patterns, so restoration of plant processes can also be expected[63]. Re-introduction of several threatened native species (e.g. saddleback) or ones similar to those driven extinct by the rat irruption would follow proof that eradication has been successful. Replacement by analogue species (e.g. the Snares snipe) and several lizards and invertebrates will be considered once rat eradication is achieved. A general increase in invertebrate, lizard, bird and bat populations is expected after initial reductions immediately following poisoning[64]. There will be immense satisfaction and large environmental gains from through effective island restoration.

Duration of Benefits

The RTRP will effectively replace the equivalent to the injured Sooty Shearwater and ensure that the risk from predation by rats will be removed indefinitely from four important island breeding colonies. The supreme advantage of going for rodent eradication as a mechanism to replace adult tïtï

[62] See Appendix C for details of how costs have been calculated.
[63] Such effects will have come directly from seed predation but also indirectly from altering tïtï abundance (tïtï burrow and destroy seedlings).

killed by the *Command* spill is that the benefits will be ongoing. If the eradication is coupled with intense community education regarding stringent quarantine precautions, there is every reason to hope that the benefit will be indefinite. Hundreds and thousands times more tïtï will be generated as a result of the investment in restoration through rat eradication, than ever were killed by the *Command* oil spill.

Public Health and Safety

The rat eradication operation will require a full health and safety plan, as required by the NZ Department of Conservation's policy. The safety plan will cover the handling of bait, work around helicopters, boat travel, etc. An example of earlier plans can be supplied to the *Command* Trustees if required.

New Zealand has now successfully promulgated scores of such aerial poisoning campaigns to eradicate rodents from islands[65]. There have never been any problems or serious public concerns once the proper professional wildlife management standards are in place.

The islands targeted in this proposal are remote and uninhabited at the time of the year proposed for the work. Just prior to the operation, the tïtï harvesters will disconnect spouting that collects water off house roofs for storage in tanks for muttonbirders' use in March-May. The spouting will be reconnected before the next birding season after the aerial operation is completed.

As further safeguard, because the New Zealand Department of Conservation will be involved in the use of toxins, it is required by it's own policy to obtain additional internal consents. It is required to notify the local 'Medical Officer of Health' who will consider, advise of and manage any human health issues.

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[64] Towns *et al.* (1990), Towns (1991), Veitch (1994), Towns (1996), Empson & Miskelly (1999), Taylor (2000a), Veitch & Clout (2002).

[65] Veitch & Bell (1990) and Veitch & Clout (2002) provide reviews of rodent eradication campaigns from New Zealand and around the world.

Likelihood of Adverse Impacts

Biodiversity risks mainly concern potential poisoning of non-target native species[66]. Brodifacoum is long-lasting in the environment so extreme care is needed to minimise loading and deliver it in a way that minimises risks to non-targets[67]. All species present on the Tïtï Islands proposed for rat eradication have been present during previous poisoning operations elsewhere in New Zealand and most of them have been monitored during at least one such operation. Monitoring has shown that while there may be some individual losses at the time of poisoning, no species is at risk at a population level[68]. The monitoring has also shown that the populations rapidly recover from any losses and will generally reach numbers far in excess of levels when rats were there.

The loss of some individual birds in the short term has already been discussed with the Rakiura tïtï birders and they are happy that the benefits of increased numbers of current native species present. Successful rat eradication will enable reintroduction of several species that were wiped out by the rats when they first got to Taukihepa, Pukeweka and Rerewhakaupoko.

Opportunities for Collaboration

The restoration initiative proposed here is important in the wider sense of fostering multicultural community-led environmental management[69]. If the *Command* Trustee Council can make the funds available for the rat eradication, it will allow the biggest and ecologically and culturally most

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[66] Colvin *et al.* (1991), Department of Conservation (1996), McClelland (1999).
[67] Godfrey (1985), Eason (1992), Eason & Spurr (1995), WHO (1995).
[68] Towns (1991), Robertson *et al.* (1993), Cole & Singleton (1996), Ogilvie (1997), Empson & Miskelly (1999).
[69] This can be appreciated by visiting the website for the proceedings of a conference organised by the kaitiaki and the tïtï research team (Howard & Moller 2001). Proceedings are recorded at http://www.otago.ac.nz/Zoology/hui/Main/default.htm)

important co-management collaboration yet promulgated between the New Zealand Department of Conservation and an '*iwi*' (Mäori tribal group)[70].

Funding from the *Command* Trustees Council for the actual rat eradication work would be ideal because the Department of Conservation is restricted in the funds it can give to the operation. It has a statutory obligation to advise the kaitiaki and assist their management. Thus the Department can offer their expertise to the *Command* Trustees Council to ensure that their investment is safe and realises its aims, but they can not fund the actual operation.

Members of the *Command* Trustees Council would be welcome to observe the main rodent eradication operation and associated field trips to monitor outcomes if they wanted.

Requested Budget

We present an approximate budget for the proposed RTRP rat eradication, outlined in Table 2 below. A detailed breakdown of the cost of the eradication is given in Appendix C.

In total we request USA$538,000 from the *Command* Spill trust funds allocated during the next 11 years, with the bulk of the expenditure in 2004 when the rat eradication operation is most likely to occur and when intensive monitoring is needed to measure rat predation and restoration efficacy. There is a resurgence of expenditure on monitoring in the last two years as surveyed plots are re-measured to check the predictions of restoration rate generated by mathematical models. Educational outreach is also concentrated in the year of rat eradication and just after. Throughout there is moderate expenditure on establishing quarantine awareness, training and precautions.

[70] The Southland Conservancy of the Department of Conservation have facilitated co-management of the Titi Islands (see http://www.otago.ac.nz/Zoology/hui/Main/Talks2/Tane.htm) and provide administrative support for the RTIAB. The previous two rodent eradications co-managed by the two groups were much smaller than the ambitious project proposed here.

Persistence will be needed to build commitment to quarantine amongst some birders.

Altogether 44%, 37%, 13% and 6% of the *Command* Trustee grant would be spent on eradication, monitoring and prediction of restoration, quarantine and educational outreach respectively (Table 2).

The figures are extremely provisional and based on an exchange rate of 1 NZ Dollar = 0.517 US$. This exchange rate has been fluctuating markedly in recent months.

The overall project is very cost effective for the *Command* Trustee Council because of several contributions from other partners in the project as detailed in Table 3. Principal amongst these is an estimated $101,000 contribution by the Department of Conservation team in servicing the actual eradication, and an initial 3 years of research of non-impact sites and measurements of population parameters by the University of Otago ($150,000 over the 3 years). Altogether help-in-kind from other partners will be valued approximately $286,000. The grand total for the entire project is therefore $824,000. We request that the *Command* Spill trust fund contributes 65% of the overall project expenditure.

Table 2. Provisional budget requested of the *Command* oil spill funds for the Rakiura Tïtï Restoration Project. Figures are in USA$.

Year	Objective 1 Eradication	Objective 2 Quarantine	Objective 3 Monitoring	Objective 4 Educational Outreach	Total for Year
2003	$25,700	$5,880	$31,000	$2,700	**$65,280**
2004	$193,000	$12,200	$36,200	$12,700	**$254,100**
2005	$13,000	$5,880	$31,200	$7,700	**$57,780**
2006	$5,000	$5,880	$38,500	$0	**$49,380**

2007	$0	$5,880	$0	$0	**$5,880**
2008	$0	$5,880	$0	$0	**$5,880**
2009	$0	$5,880	$0	$0	**$5,880**
2010	$0	$5,880	$0	$0	**$5,880**
2011	$0	$5,880	$0	$0	**$5,880**
2012	$0	$5,880	$24,400	$0	**$30,280**
2013	$0	$5,880	$38,200	$7,700	**$51,780**
All years	$236,700	$71,000	$199,500	$30,800	**$538,000**
% each objective	44%	13%	37%	6%	

Table 3. Value of support provided by other partners to the Rakiura Tïtï Restoration Project. Figures are in USA$.

Year	Objective 1 Eradication	Objective 2 Quarantine	Objective 3 Monitoring	Objective 4 Educational Outreach	Total for Year
2003	8500	1000	50500	$0	**$60,000**
2004	102000	1000	50500	$0	**$153,500**
2005	1000	1000	50500	$0	**$52,500**
2006	1000	1000	500	$0	**$2,500**
2007	1000	1000	500	$0	**$2,500**
2008	1000	1000	500	$0	**$2,500**
2009	1000	1000	500	$0	**$2,500**
2010	1000	1000	500	$0	**$2,500**
2011	1000	1000	500	$0	**$2,500**
2012	1000	1000	500	$0	**$2,500**
2013	1000	1000	500	$0	**$2,500**
All years	119500	11000	155500	$0	**$286,000**
% each objective	42%	4%	54%	0%	

Conclusion

Even including the value of inputs from other partners, the Rakiura Tïtï Restoration Project will only expend just over half of the cost of the Anacapa Island eradication project. This is extremely cost-effective especially if one considers that the Rakiura project will eradicate rats from an area 3 times larger than cleared of rats at Anacapa. If the value of contributions from other partners is not considered, the *Command* spill trust funds would contribute about a third of the expenditure invested on Anacapa.

All methods for eradication, managing risks and monitoring outcomes are in proven and refined. Experienced and expert teams will secure the investment in the restoration effort. Computer simulations suggest recovery of the injury to tïtï is most likely to be rapid. Multiple long-term benefits to four island ecosystems and several non-target endemic species are certain outcomes. A model for international and cross-cultural collaboration to mitigate the effects of a significant oil spill will be promulgated. Education for heightened environmental awareness will bring lasting benefits for conservation. The Rakiura Tïtï Restoration Project will build confidence that enlightened research, management and legislation can combine to heal environmental injury resulting from negligence.

We urge the *Command* Spill Trustee Council to fund the Rakiura Tïtï Restoration Project.

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